AIRPLANE-GENERAL.

The Glenn L. Martin Company Model 4-0-4 airplane is a forty-passenger commercial transport. The airplane is an all metal, low wing, twin-engine monoplane with full cantilever wing and tail surfaces, semi-monocoque fuselage and fully retractable tricycle type landing gear with steerable nose wheel. For external appearance and dimensions, see figure 12; and for general interior appearance and arrangement, see figure 14.

DIMENSIONS AND LEADING PARTICULARS.

Airplane-General

Wing Span	93 feet 3.50 inches
Empennage Span	36 feet 5.68 inches
Length	74 feet 7.00 inches
Height (to top of fin)	28 feet 8.31 inches
Propeller ground clearance (level landing)	1 foot 6.5 inches
Propeller fuselage clearance	1 foot 4.6 inches
Maximum gross take-off weight (structural)	45,000 pounds
Maximum gross take-off weight (wet)	→ 44,900 pounds
Maximum gross take-off weight (dry)	41,500 pounds
Maximum gross landing weight (structural)	43,000 pounds
Maximum gross landing weight (wet)	→ 43,000 pounds
Maximum gross landing weight (dry)	40,200 pounds
Power loading (at take-off gross weight per brake horsepower)	9.4 pounds/BHP
Wing loading (at take-off gross weight)	52.08 pounds/square foot
Wing loading (at landing gross weight)	49.77 pounds/square foot

WINGS

Area (flaps retracted, including ailerons)	864 square feet
Aspect ratio	10.0
Airfoil section	Root GLM W-16 Tip GLM W-16
Incidence (to fuselage)	+3 degrees
Dihedral	Center panel +3 degrees Outer panel +10 degrees
Sweepback (25 percent chord line)	0 degree
Root chord	13 feet 8.0 inches
Tip chord	4 feet 11.6 inches
Mean aerodynamic chord (projected)	9 feet 11.9 inches

WING FLAPS

Span	59 feet
Area (total, excluding vane)	150.3 square feet
Flap setting	45 degrees

Ailerons

Area (each; total, including tab)	20.9 square feet
Angular deflection (up)	30 degrees
Angular deflection (down)	15 degrees
Area of tab (each)	1.35 square feet
Angular deflection of trim tab (up) aileron neutral	12 degrees
Angular deflection of trim tab (down) aileron neutral	12 degrees
Balance action, trim tab deflection down (aileron 30 degrees up)	6 degrees
Balance action, trim tab deflection up (aileron 15 degrees down)	3 degrees

Horizontal Stabilizer

Area (total projection, including area in fuselage)	210 square feet
Dihedral	8 degrees
Angular deflection (up) flap 45 degrees down	2.12 degrees
Angular deflection (down) zero degrees flap	0 degrees
Normal setting (relative to longitudinal axis)	+1.4 degrees

Elevators

Area (each; total, including tab)	33.86 square feet
Angular deflection (up) stabilizer neutral	30 degrees
Angular deflection (down) stabilizer neutral	18 degrees
Tab area (each elevator)	5.78 square feet
Angular deflection of trim tab up (elevator in neutral)	10 degrees
Angular deflection of trim tab down (elevator in neutral)	22 degrees
Servo deflection of trim tab down (elevator 30 degrees up)	7 degrees
Servo deflection of trim tab up (elevator 18 degrees down)	4.5 degrees
Angular down deflection of spring tab with elevator up	31 degrees
Angular up deflection of spring tab with elevator down	24 degrees

Rudder

Area (including tab)	57.05 square feet
Angular deflection (right)	25 degrees
Angular deflection (left)	25 degrees
Area of tab	4.94 square feet
Angular deflection of trim tab (right)	17 degrees 30 minutes
Angular deflection of trim tab (left)	17 degrees 30 minutes
Spring tab throws (with full rudder)	20 degrees

Fuselage

Maximum cross section (outside)	9 feet 8.0 inches
Maximum cross section (inside)	9 feet 2.0 inches
Cabin width of floor (inside trim line)	7 feet 11.0 inches

Seating Accommodations

Crew	4
Passengers	40
Observer	1

Cargo Accommodations*

Forward compartment (not including 12 cubic feet of snack cabinet)	148 cubic feet
Belly compartment (not including area above access doors)	105 cubic feet
Carry-on Baggage compartment	63 cubic feet
Coat Room (Usable baggage space)	5 cubic feet

*Refer to Chapter 4 for cargo loading and weight distribution

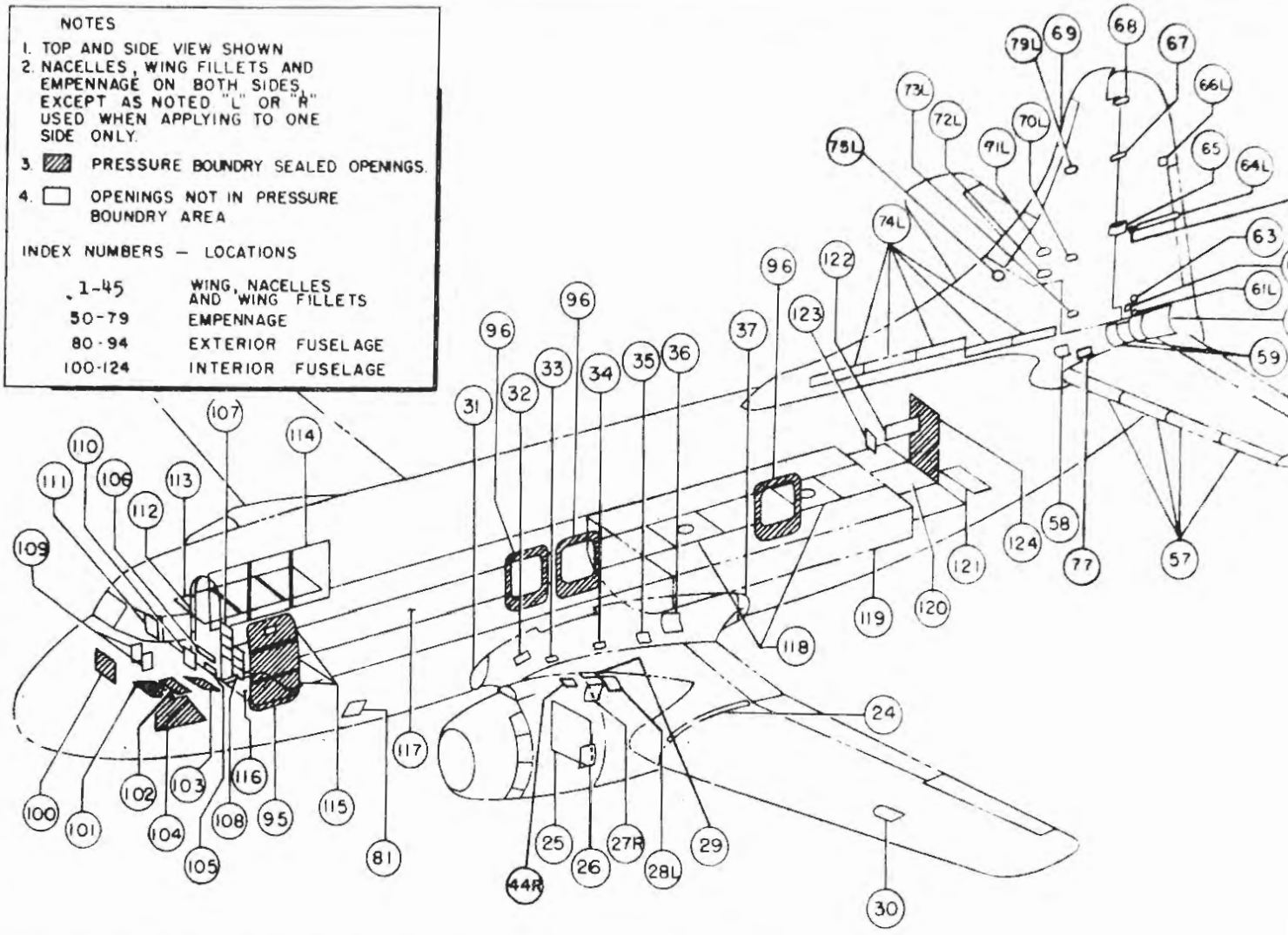
ACCESS DOORS, COVERS, PANELS, AND HATCHES GENERAL (See figure 11).

Access doors, covers, panels, and hatches are provided throughout the airplane for accessibility to the interior structure, controls, mechanisms, wiring, plumbing, and equipment. These doors are secured in place by screws, spring type fasteners, or latch dogs. Access doors in the pressure boundry area of the fuselage (See figure 14) are cross-hatched on figure 11 for identification. These doors are provided with seals to prevent cabin pressure leakage. The cargo compartment liner is made up of removable panels so that one or more may be removed for access behind the liner. All access doors must be secured before flight. Access doors, as shown on figure 11, sheets 1 and 2, are numbered in index form and are listed on the accompanying charts along with the various equipment and structure accessible through the openings. The access doors numbers are in block form as shown in notes on door charts.

Effect Of Access Doors Opening In Flight.

A series of test flights have been made to determine the effects of certain access doors coming open in flight. The results of these tests indicate that the ADI filler, alcohol filler, and oil tank filler access doors produce no ill effects from the stall speeds up to indicated speeds of 200 M.P.H.

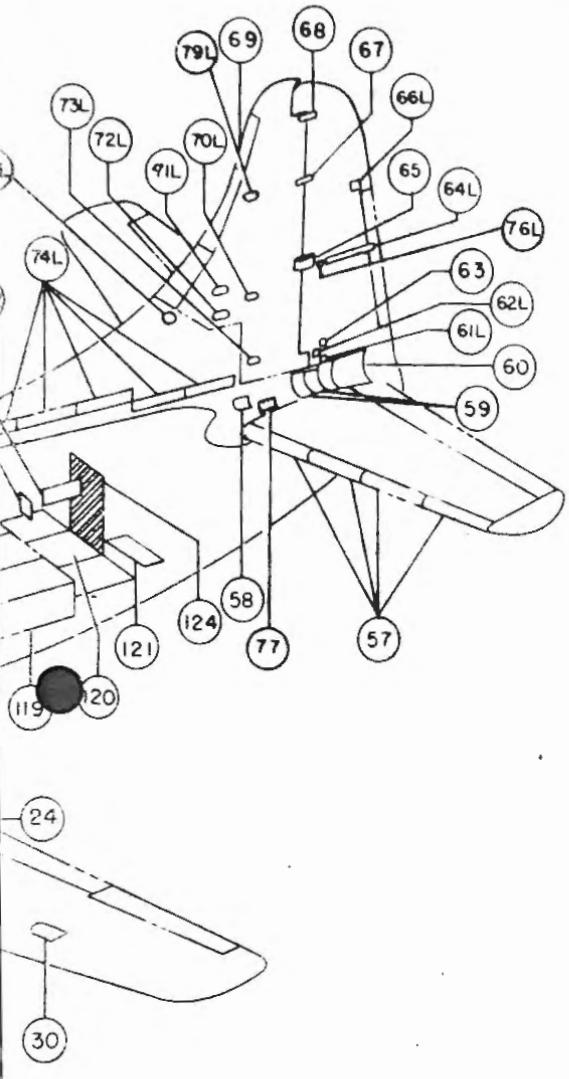
Tests were also conducted with the upper wing fuel tank access door open and the filler cap attached to its retaining chain hanging loose on top of the wing. With the flaps in the take-off position no effects were apparent throughout the flap placard speed zone. With the flaps up or extended less than five degrees, rather sharp buffeting of the ailerons occured. The buffeting was very erratic but resulted in no reduction in aileron effectiveness. However, a trim-shift of about five degrees of aileron tab did result.


NOTES
1. TOP AND SIDE VIEW SHOWN
2. NACELLES, WING FILLETS AND EMPENNAGE ON BOTH SIDES EXCEPT AS NOTED "L" OR "R" USED WHEN APPLYING TO ONE SIDE ONLY.
3. PRESSURE BOUNDRY SEALED OPENINGS.
4. OPENINGS NOT IN PRESSURE BOUNDRY AREA
INDEX NUMBERS — LOCATIONS
1-45 WING, NACELLES AND WING FILLETS
50-79 EMPENNAGE
80-94 EXTERIOR FUSELAGE
100-124 INTERIOR FUSELAGE

OUTER AND CENTER WINGS, NACELLES, AND WING FILLETS (TOP AND INTERNAL).

24. UPPER WING SPLICE FAIRINGS -- Wing Splice Attachment Angle.
25. FIREWALL ACCESS DOORS -- Engine Accessory Section.
26. COWLING ACCESS DOORS -- For Insertion Of Ground Fire Extinguisher Nozzle, Both Sides Of Each Nacelle.
27R. OIL TANK FILLER ACCESS DOORS -- Right Side Each Nacelle.
28L. OIL TANK SEQUENCE VALVE ACCESS DOORS -- Left Side Each Nacelle.
29. BOLT ACCESS DOORS -- Engine Mount Fitting Bolts, Oil Tank Vent Line Firewall Connection.
30. FUEL TANK UPPER FILLER DOORS -- Fuel Tank Top Wing Filler.
31. WING FILLET REMOVABLE NOSE SECTIONS -- Interior Inspection.
32. WING FILLET ACCESS DOORS -- Interior Inspection.
33. WING FILLET ACCESS DOORS -- Interior Inspection.
34. WING FILLET ACCESS DOORS -- Interior Inspection.
35. WING FILLET ACCESS DOORS -- A.D.I. Tank Plumbing In Left Fillet. Alcohol Tank Plumbing In Right Fillet.
36. WING FILLET TANK FILLER DOORS -- A.D.I. Tank Filler In Left Fillet. Alcohol Tank Filler In Right Fillet.
37. WING FILLET REMOVABLE TAIL SECTIONS -- Interior Inspection.
44R. PRIMARY COMPRESSOR OIL TANK ACCESS DOOR -- Oil Tank Filler. (Right Nacelle Only)

Figure 11.



EMPENNAGE (UPPER PORTION)

57. HORIZONTAL STABILIZER HEATED LEADING EDGE SECTIONS -- Interior Inspection.
58. EMPENNAGE FAIRING ACCESS DOORS -- Fin Front Spar Attachments, Interior Structure, Anti-Icing Heat Duct Flexible Connection.
59. EMPENNAGE FAIRING ACCESS DOORS -- Fin Rear Spar Attachments, Horizontal Stabilizer Front Spar Attachments, Interior Structure.
60. TAIL CONE SADDLE FAIRING -- Horizontal Stabilizer Rear Spar, Elevator Torque Tube And Stabilizer Actuator.
61L. RUDDER ACCESS DOOR (Left Side Only) -- Rudder Torque Tube Attachment, Rudder Spring Tab Rod.
62L. RUDDER ACCESS DOOR (Left Side Only) -- Rudder Torque Tube Attachment.
63. RUDDER ACCESS DOORS -- Rudder Spring Tab Idler Arm.
64L. RUDDER TRIM TAB ROD COVER (Left Side Only) -- Tab Rod Attachment.
65. RUDDER HINGE COVERS -- Rudder Hinge, Rudder Trim Tab Actuator.
66L. RUDDER ACCESS DOOR (Left Side Only) -- Rudder Trim Tab Hinge Pin Attachment.
67. RUDDER HINGE COVERS -- Rudder Hinge.
68. RUDDER HINGE COVERS -- Rudder Hinge.
69. FIN HEATED LEADING EDGE -- Interior Inspection.
70L. FIN ACCESS DOOR (Left Side Only) -- Rudder Trim Tab Linkage And Drum.
71L. FIN ACCESS DOOR (Left Side Only) -- Fin Anti-Icing Duct.
72L. FIN ACCESS DOOR (Left Side Only) -- Fin Anti-Icing Duct, Alignment Pins.
73L. FIN ACCESS DOOR (Left Side Only) -- Rudder Trim Tab Cables And Disconnects.
74L. DORSAL FIN ACCESS DOORS (Left Side Only) -- Interior Dorsal Fin Structure, And Fin Anti-Icing Duct.
75L. DORSAL FIN ACCESS DOOR (Left Side Only) -- Vertical Fin Alignment Pin.
76L. RUDDER ACCESS DOOR (Left Side Only) -- Rudder Spring Tab Linkage
77. EMPENNAGE FAIRING ACCESS DOORS -- Interior Structure.
79L. FIN ACCESS DOOR (Left Side Only) -- Anti-Icing Duct Temperature Bulb.

FUSELAGE EXTERIOR

81. HYDRAULIC TEST OUTLET DOOR -- Ground Test Disconnect Fittings.
95. FORWARD ENTRANCE DOOR -- Entrance To Cargo And Radio Compartments And Galley.
96. ESCAPE HATCHES -- Passenger Emergency Escape Hatches.

Figure 11. (Sheet 2 of 2 Sheets) Access Doors, Covers, Panels, And Hatches

terior Inspection.
Fin Front Spar Attachments, Interior Structure, Anti-Icing Heat Duct Flexible Connection.
Fin Rear Spar Attachments, Horizontal Stabilizer Front Spar Attachments, Interior Structure.

ontal Stabilizer Rear Spar, or Torque Tube And Stabilizer tor.
) -- Rudder Torque Tube Attachment, Rudder Spring Tab Rod.
) -- Rudder Torque Tube Attachment.
g Tab Idler Arm.
de Only) -- Tab Rod Attachments.
ge, Rudder Trim Tab Actuator.
) -- Rudder Trim Tab Hinge Pin Attachment.
ge.
ge.
Inspection.
-- dder Trim Tab Linkage And Drum.
-- Fin Anti-Icing Duct.
-- Fin Anti-Icing Duct, Alignment Pins.
-- Rudder Trim Tab Cables And Disconnects.
Only) -- Interior Dorsal Fin Structure, And Fin Anti-Icing Duct.
Only) -- Vertical Fin Alignment Pin.
) -- Rudder Spring Tab Linkage.
Interior Structure.
-- Anti-Icing Duct Temperature Bulb.

nd Test Disconnect Fittings.
To Cargo And Radio Compart-
Galley.
ency Escape Hatches.

FUSELAGE INTERIOR

100. BULKHEAD PRESSURE ACCESS PANEL -- Forward Side Of Instrument Panel, Front Of Pedestal, Throttle Reversing Lock Bar And Solenoid, Fire Extinguishing Controls, And Windshield Wiper Units.
101. PRESSURE SHELF ACCESS PANEL (FORWARD) -- Inside Of Pedestal, Pedestal Control Quadrants, Elevator Tab Chains And Sprockets, Propeller Arming And Reversing Micro Switches.
102. PRESSURE SHELF ACCESS PANEL (CENTER) -- Aft Inside Of Pedestal; Rudder And Aileron Tab Control Units, Chains, And Sprockets. Control Cables.
103. PRESSURE SHELF ACCESS PANEL (AFT) -- Control Cables, Landing Gear Up-Lock Release.
104. WHEEL WELL PRESSURE ACCESS PANELS -- (Left Side) -- Brake Control Valves, Brake And Rudder Pedal Linkage, Torque Tube Stops, Hydraulic Plumbing, Steer Control Valve And Linkage, Windshield Wiper Shut-Off Valve, And Hydraulic Depressurization (By-Pass) Valve
105. COCKPIT STEP ACCESS PANEL -- Landing Gear Up-Lock Release Handle And Emergency Down Line Selector Valve.
106. COCKPIT STEP ACCESS PANEL -- Cables And Pulleys.
107. MAIN CIRCUIT BREKER ACCESS PANELS -- Circuit Breakers Relays, Bus Bars, And Electrical Equipment.
108. HYDRAULIC RESERVOIR ACCESS PANELS -- Hydraulic Reservoir Filler, Vent Line And Filter.
109. PEDESTAL ACCESS COVERS (Above Floor) -- Interior Of Pedestal.
110. PILOT'S CONSOLE ACCESS COVER -- Interior Of Console, Gust Lock Linkage, Steering Gear Box And Linkage.
111. CO-PILOT'S CONSOLE ACCESS COVER -- Interior Of Console, Landing Gear Warning Horn, And Fire Detection Warning Horn.
112. COCKPIT DOOR FRAME ACCESS PANELS -- Electrical Wiring And Interior Inspection.
113. RADIO RACK BOTTOM ACCESS PANELS -- Radio Wiring.
114. RADIO RACK SIDE ACCESS PANEL -- Radio Equipment.
115. FORWARD ENTRANCE DOOR ACCESS PANELS -- Interior Structure And Latching Mechanism.
116. REMOVABLE FLOOR PANEL (At Fwd. Ent. Door) -- Hydraulic Lines, Ducts, Electrical Wiring And Cabin Conditioning Equipment.
117. REMOVABLE CENTER FLOOR PANELS -- Top Access To Equipment In Belly Of Airplane.
118. CABIN FLOOR ACCESS DOORS -- Cargo Compartment.
119. CARGO COMPARTMENT LINER PANELS -- Interior Structure, Control Cables Anti-Icing Ducts, And Ramp Hydraulic Lines On Left Side.
120. REMOVABLE FLOOR PANEL -- Cabin Pressure Regulating Equipment And Ramp Hydraulic Lines.
121. FIXED STEP ACCESS PANEL (Removable Tread) -- Ramp Hinge Fittings.
122. HOSTESS PANEL ACCESS DOOR -- Electrical Equipment And Wiring, And Chimes.
123. COAT ROOM ACCESS PANEL -- Toilet Plumbing.
124. AFT CABIN PRESSURIZED DOOR -- Passenger Entrance To Cabin.

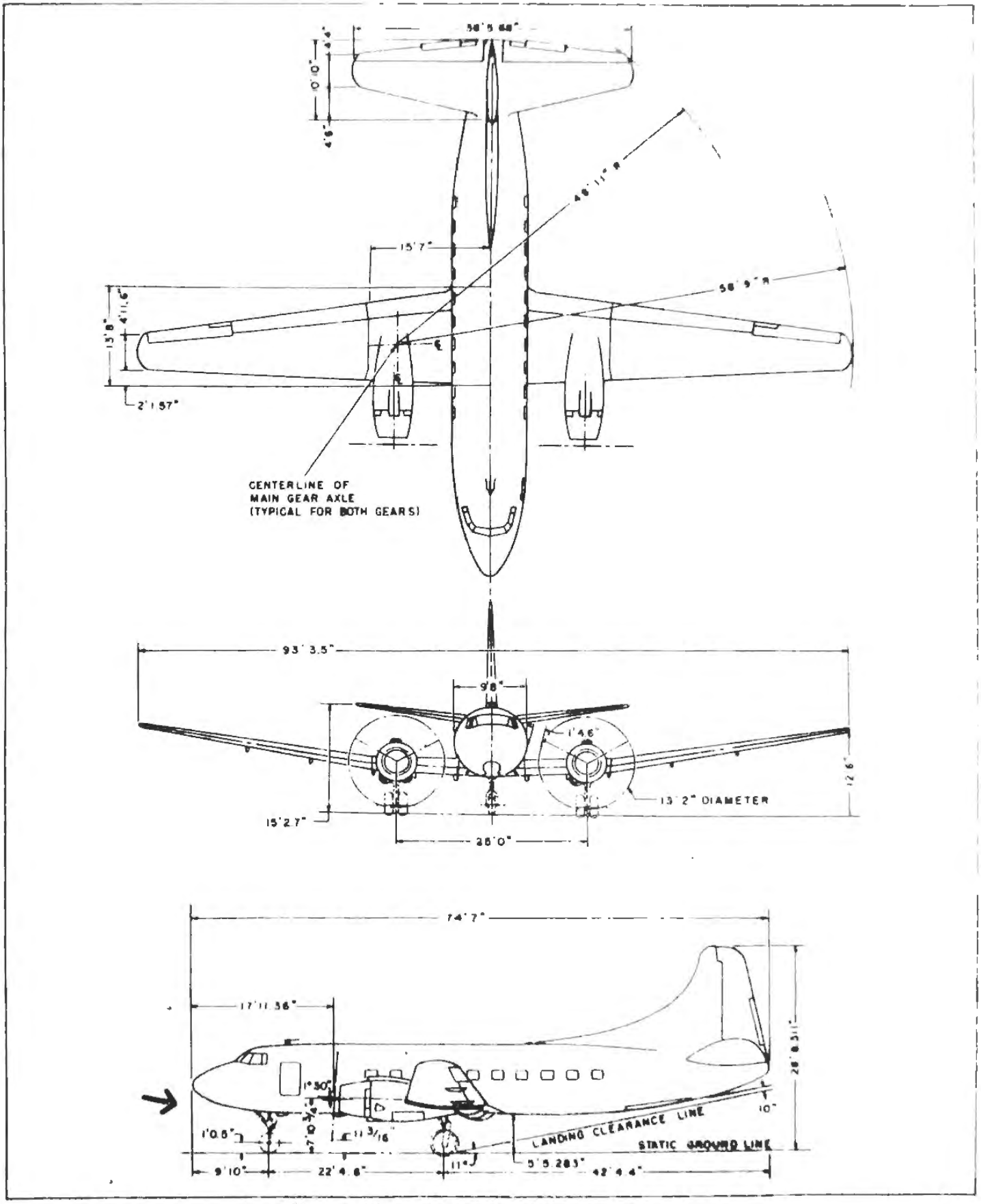
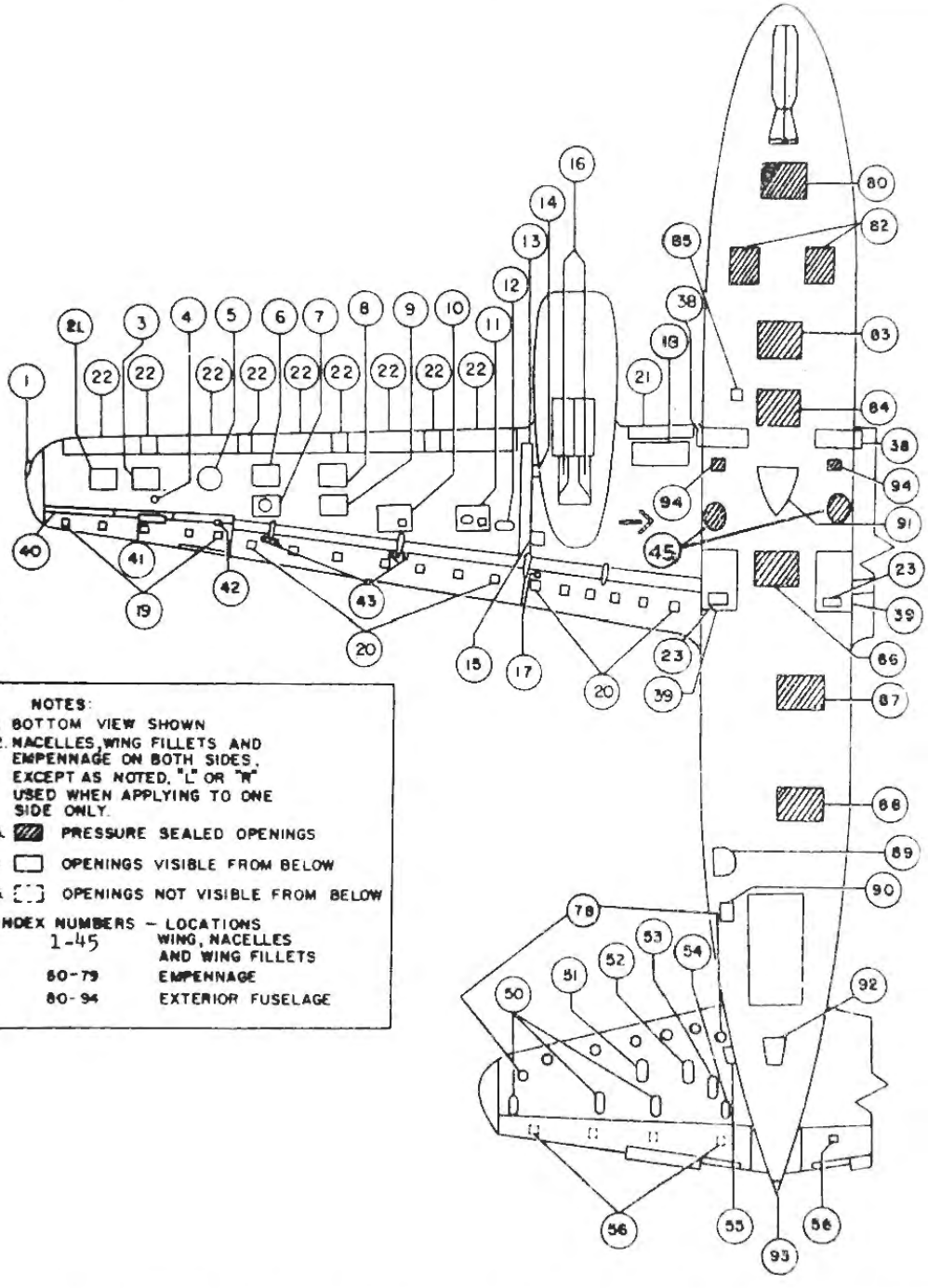


Figure 12. Airplane Three View Diagram


NOTES:
1. BOTTOM VIEW SHOWN
2. NACELLES, WING FILLETS AND EMPENNAGE ON BOTH SIDES, EXCEPT AS NOTED, "L" OR "R" USED WHEN APPLYING TO ONE SIDE ONLY.
3. PRESSURE SEALED OPENINGS
4. OPENINGS VISIBLE FROM BELOW
5. OPENINGS NOT VISIBLE FROM BELOW
INDEX NUMBERS - LOCATIONS
1-45 WING, NACELLES AND WING FILLETS
60-79 EMPENNAGE
80-94 EXTERIOR FUSELAGE

OUTER AND CENTER WINGS, NACELLES, AND W

1. NAVIGATION LIGHT COVERS -- Navig
2L. WING ACCESS DOOR (Left Wing Only
3. WING ACCESS DOORS -- Interior St
Wires, Land
Fuel Altern
4. WING ACCESS DOORS -- Aileron Bel
5. LANDING LIGHT DOORS -- Landing L
6. OUTBOARD CELL TANK ACCESS DOORS
7. OUTBOARD CELL TANK ACCESS DOORS
8. OUTBOARD CELL TANK ACCESS DOORS
9. OUTBOARD CELL TANK ACCESS DOORS
10. CENTER CELL TANK ACCESS DOORS --
11. INBOARD CELL TANK ACCESS DOORS -
12. FUEL BOOSTER PUMP ACCESS DOORS -
13. LOWER WING SPLICE COVERS -- Wing
Unit
lief
turn
14. LOWER FRONT SPAR WING SPLICE COV
15. LOWER REAR SPAR SPLICE COVERS --
16. NACELLE ACCESS DOORS -- Interior
Anti-Ici
Heater F
17. INBOARD WING FLAP ACCESS DOOR --
18. CENTER WING TUNNEL DOORS -- Hydr
And
Gear
Fuel
tion
Side
sure
And
Stop
19. AILERON ACCESS DOORS -- Interior
20. WING FLAP ACCESS DOORS -- Interi
21. CENTER WING HEATED LEADING EDGE
22. OUTER WING HEATED LEADING EDGE SE
23. LOWER WING FILLET ACCESS DOORS --
(Within #39 Doors)
38. LOWER WING FILLET ACCESS DOORS
39. LOWER WING FILLET ACCESS DOORS (
40. TRAILING EDGE ACCESS DOORS -- E
41. TRAILING EDGE COVE ACCESS DOOR
42. TRAILING EDGE COVE ACCESS DOOR
43. OUTER WING FLAP ACCESS DOORS --
45. WING CENTER SECTION ACCESS

Figure 11. (Sheet 1 of 2 Sheets) Access Do

NACELLES, AND WING FILLETS.

? COVERS -- Navigation Lights.
1 (Left Wing Only -- Flux-Gate Transmitters. And Wing Structure.
?S -- Interior Structure, Electrical And Radio Wires, Landing Light, Aileron Bellcrank, Fuel Alternate Vent Check Valve.
?S -- Aileron Bellcrank Bolt.
?ORS -- Landing Light.
?NK ACCESS DOORS -- Forward Fuel Cell, Vent Relief And Check Valve.
?NK ACCESS DOORS -- Aft Fuel Cell And Surge Valve.
?NK ACCESS DOORS -- Forward Fuel Cell.
?NK ACCESS DOORS -- Aft Fuel Cell And Outer Quantity Transmitter.
? ACCESS DOORS -- Both Fuel Cells, Quantity Transmitter And Drip Stick.

?R ACCESS DOORS -- Both Fuel Cells Quantity Transmitter, Drip Stick, And Underwing Fuel Filler Opening.
?P ACCESS DOORS -- Fuel Booster Pump And Fuel Tank Sump Drain.
?E COVERS -- Wing Splice And Booster Pump Electrical Units. Fuel Crossfeed Line, Thermal Relief Valve, (left side only), Vapor Return Line Check Valve.
? WING SPLICE COVERS -- Wing Front Spar Splice.
? SPLICE COVERS -- Wing Rear Spar Splice.
?ORS -- Interior Of Aft Nacelle, Anti-Icing Heaters, Anti-Icing Heater Junction Box, Anti-Icing Heater Fuel Panel.
? ACCESS DOOR -- Interior Wing Flap Structure.
?L DOORS -- Hydraulic Lines Including Pump Pressure And Suction, Main And Emergency Brakes, Gear Up And Down; CO_2 Line, Cross Feed Fuel Line, Engine Control Cables, Ignition Lead, Electrical Cable Run On Right Side Only - Air Conditioning High Pressure Connection, Pressure Duct Damper And Operating Solenoid, CO_2 Direction Stop Valve.
?ORS -- Interior Aileron Structure.
? DOORS -- Interior Wing Flap Structure.

?D LEADING EDGE SECTIONS -- Interior Inspection.
? LEADING EDGE SECTIONS -- Interior Inspection.
? ACCESS DOORS -- A.D.I. Tank In Left Fillet; Alcohol Tank In Right Fillet.
? ACCESS DOORS (FWD.) -- Interior Inspection.
? ACCESS DOORS (AFT) -- A.D.I. Tank, Pump, Solenoids, Under Wing Filler And Drain Valves, And Strainer In Left Fillet. Alcohol Tank, Pumps, Filter, Under Wing Filler And Drain Valve, And Pressure Relief Valves in Right Fillet.
?ESS DOORS -- Electrical Wiring, Interior Inspection.

?E ACCESS DOOR -- Aileron Bellcrank, Aileron Push Rod And Interior Inspection.
?E ACCESS DOOR -- Aileron Trim Tab Drum And Interior Inspection.
?CESS DOORS -- Interior Inspection Forward Of Flap Spar.

?TION ACCESS DOORS - Interior Structure Inspection

EMPENNAGE (LOWER SURFACE).

50. HORIZONTAL STABILIZER ACCESS DOORS -- Interior Structure.
51. HORIZONTAL STABILIZER ACCESS DOORS -- Interior Structure, Elevator Trim Tab Linkage And Drum.
52. HORIZONTAL STABILIZER ACCESS DOORS -- Interior Structure, Elevator Trim Tab Cables And Disconnects.
53. HORIZONTAL STABILIZER ACCESS DOORS -- Interior Structure, Elevator Spring Tab Linkage.
54. HORIZONTAL STABILIZER ACCESS DOORS -- Interior Structure, Elevator Spring Tab Linkage.
55. EMPENNAGE LOWER FAIRING ACCESS DOORS -- Horizontal Stabilizer Hinge Bolts And Fittings.
56. ELEVATOR ACCESS DOORS -- Interior Elevator Structure.
78. HORIZONTAL STABILIZER ACCESS DOORS -- Seven Doors On Bottom Surface Of Each Side For Interior Inspection.

FUSELAGE EXTERIOR (LOWER SURFACE).

80. AIR CONDITIONING ACCESS HATCH -- Air Conditioning Equipment, Ground Air Conditioning Connection, "C" And "H" Valve Actuator, "A", "B", "B_2", "F" And "H" Valves, Pressure Ratio And By-Pass Valves, Cold Air Duct Temperature Bulb, Control Cables And Turnbuckles, Hydraulic Lines, Emergency Hydraulic Pump, Emergency Relief Valve, Emergency Landing Gear Down Line Relief Valve, And Electrical Wiring.
82. BLOWER ACCESS HATCHES -- Recirculation Air Blowers, Control Cables And Ducting. Left Hatch - Hydraulic Lines And "G" Valve Actuator, Plenum Chamber Screen, "C" Valve Switch. Right Hatch - Plenum Chamber And "E" & "F" Valve Actuators.
83. HEATER ACCESS HATCH -- Heaters And Associated Equipment, Control Cables And Hydraulic Lines. "G" And "C" Valves, Belly Junction Box, Fire Detector Relay Panels, Propeller RPM And Reversing Boxes.
84. ELECTRICAL ACCESS HATCH -- Battery, Electrical Equipment, Electrical -- Wiring, Control Cables And Hydraulic Lines. Cabin Heater Ignition Units, Flasher Unit, Automatic Feathering Propeller Control Box, CO_2 Direction Stop Valve.
85. EXTERNAL POWER DOOR -- Ground Power Connection And Interphone Jack, External Power Circuit Breaker.
86. REAR SPAR ACCESS HATCH -- Anti-Icing Mixing Box And Ducts, Flap Hydraulic Valves And Lines, Flap Follow-Up System, And Control Cables, CO_2 Cylinders, Aileron Gust Lock, Aileron Boost System, CO_2 Direction Stop Valve.
87. CARGO ACCESS HATCH -- Cargo Compartment.
88. CARGO ACCESS HATCH -- Cargo Compartment.
89. TOILET ACCESS HATCH -- Toilet Tank Flushing Fittings.

90. RAMP CONTROL ACCESS DOOR -- Ground Ramp Control Handle.
91. REMOVABLE FAIRING -- Interior Inspection.
92. TAIL ACCESS HATCH -- Interior Structure, Elevator And Rudder Controls Gust Locks, And Quadrants, Stabilizer Actuator, And Horizontal Stabilizer Attachments.
93. NAVIGATION LIGHT COVER -- Navigation Lights.
94. FUSELAGE CENTER SECTION DOORS -- Hydraulic Lines, Fuel Lines, Electrical Wires, Engine Control Cables, And Pressure Bulkhead With Cable, Hose And Wiring Pressure Seals.

AIRPLANE HANDLING-GENERAL.

Handling of the airplane should be accomplished in such a manner as to avoid damage to the airplane as well aa other equipment and personnel.

Locking Of Control Surfaces.

The control surfaces are locked by means of a cable controlled locking device operated by a handle which is normally folded against the left side of the pilots' compartment. This handle, when engaged, locks all controls in a neutral position. Locking is accomplished by pulling the control (gust) lock handle inboard and forward until engaged on detent; then moving all control surfaces slightly about an estimated neutral until lockpins become engaged. These lockpins, when engaged will prevent further movement of the controls. The control lock handle, when in the engaged position, extends over the left side of the pilot's control wheel. The control lock can be disengaged either by releasing the lever on the handle or exerting an approximate 40 pound pull on the co-pilot's control column. In either method of disengaging the control lock, the control column should be prevented from falling free against the elevator "down" stops. Refer to Chapter 8 for further description of control lock system.

Control surfaces must be locked at all times when the pilots' compartment is unattended and the airplane is outside the hangar.

Landing Gear Lock Pins (See figure 1).

Landing gear lock pins (404-4900170) are used as an additional safety measure for locking the nose and main gears in the "down" position when the airplane is on the ground. A long red weighted streamer is attached to the pins to serve as a warning that the pins are installed in the gears. These pins are installed in the jury struts of both the nose and main gears and are held in place by hooking the attached bungee cord over the projecting end of the pin. Landing gear pins supplied to the stations shall be installed rather than using the pins which are aboard the plane. It is not necessary to install the landing gear safety pins on through flights. If the plane is to be on the ground longer than normal ground time or if the landing gear doors are opened for any reason, the pins shall be installed. For stowage location of pins aboard the plane, see "Miscellaneous Stowed and Loose Equipment", Chapter 4.

WARNING

Landing gear lock pins must be removed from the nose and main gears of the airplane before taxiing out for take-off.

Parking.

During normal weather conditions the airplane may be parked by setting the parking brakes, locking the control surfaces, installing landing gear lock pins, and chocking the wheels. Refer to AIRPLANE PARKING of this chapter for procedure on parking of the airplan

Mooring (See figure 1).

Anytime the airplane is parked where adverse weather conditions may jeopardize its safety it should be moored (tied down). Provisions for mooring the airplane, in addition to the normal parking procedure, are incorporated in the center flap hinge fitting at station 272.5 on each outer wing panel, and at the tail support fitting on the fuselage at station 900. The nose gear is also lashed down when the aircraft is moored to prevent tail tipping. When it is necessary to moor the airplane completely due to extreme weather conditions, additional mooring ropes may be attached to the landing gears where the drag struts attach to the shock struts. Also, the towing lugs on the main gears may be used to attach additional mooring ropes. The mooring ropes used should be at least one inch in diameter. Refer to AIRPLANE MOORING of this chapter for mooring procedures.

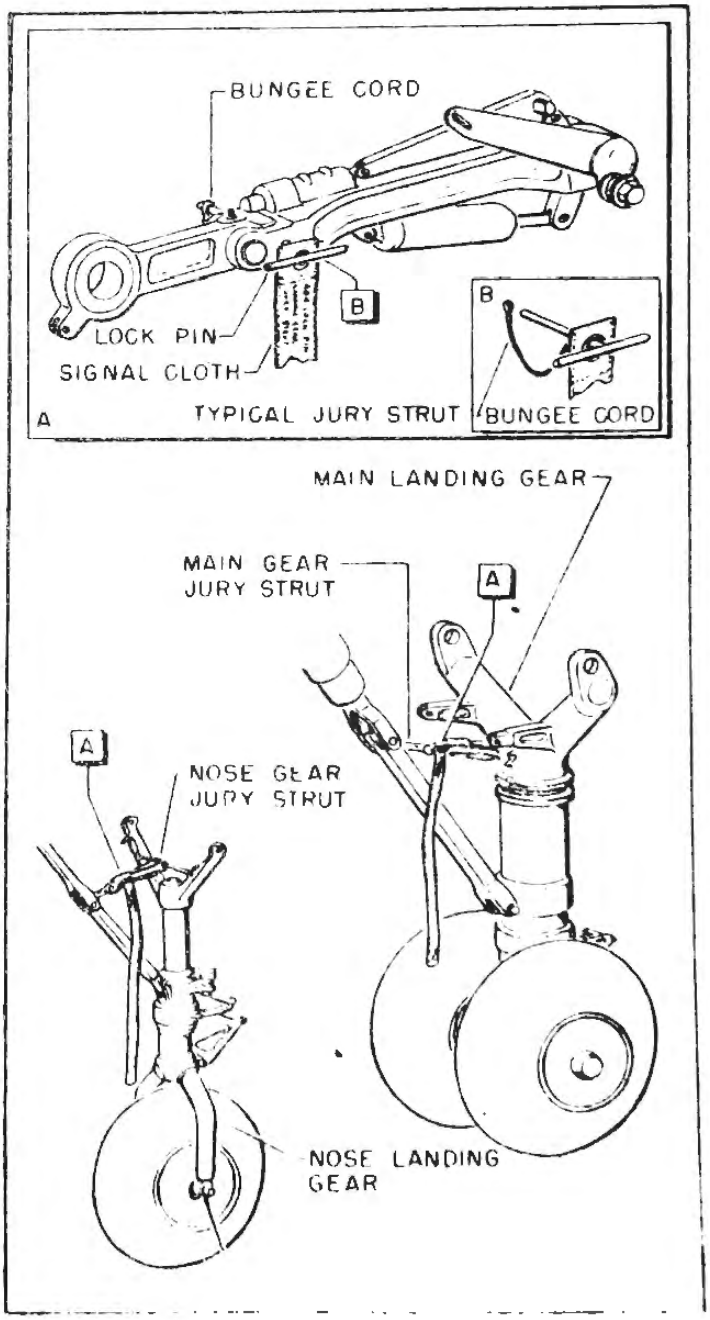


Fig. 1. Landing [illegible]

TAXIING.

The taxiing characteristics of the Model 4-0-4 are normal for tricycle geared airplanes. The nose wheel is steerable through 59½ degrees each side of neutral to permit turning about one main gear. The nose wheel steering can be used if desired, but if it is not used, the nose wheel will caster when brakes or unbalanced power is applied as on an airplane without steering control. During taxiing operations, when reverse thrust is used it is recommended that the controls be locked in order to eliminate the necessity of monitoring controls. Rapid acceleration of engines and/or sudden application of brakes should be avoided to eliminate the possibility of overbalancing the airplane.

Towing (See figure 2).

Each main landing gear strut is designed for an applied load of 6620 pounds acting through a tow fitting in a fore and aft plane and 30 degrees each side of neutral. The nose gear strut is also designed for an applied load of 6620 pounds acting through the tow fitting on the forward side in any direction in a plane parallel to the ground, provided the nose gear strut is compressed at least 2½ inches (to disengage strut centering cam), and may be turned 360 degrees with the torque arm disconnected.

A tow bar (4041C10527-19) is used to tow the airplane from the nose gear. This tow bar is attached to the tow fitting on the nose gear strut by means of a 5/16 bolt secured to the tow bar and held in place by a safety pin inserted in the hole in the bolt shank. To insure that the load applied in towing at the gear does not exceed the design load of the strut, a shear bolt is used to secure the tow bar attachment fitting to the tow bar.

The nose gear torque arm must be disconnected prior to towing the airplane at the nose gear to prevent damage to the steering mechanism. The torque arm is disconnected by first removing the safety pin from the disconnect pin, and then removing the disconnect pin from the torque arm. The torque arm is then disconnected by pulling the lower arm from the upper arm. The bottom arm is lowered onto the bumper at the forward end and the upper arm is attached to the nose gear strut by use of the chain or disconnect pin. Torque arm must be reconnected immediately when towing operation is completed.

Two press fit bushings are incorporated in the lower torque arm and one in the upper arm. These bushings may become loose, worn or lost in service and must be checked whenever the torque arm is disconnected or connected. Corrective action must be taken if any of the above conditions exist in the bushings to prevent excessive nose wheel vibrations during take-off or landing.

Lugs on the forward and aft sides of each of the main gear struts are used for the attachment of ropes or cables for forward and rearward towing.

Towing With One Or Both Engines Removed.

If absolutely necessary to tow the airplane while one or both of the engines are removed, ballast must be added to the forward section of the fuselage. This ballast is added by attaching weights to the removable ballast fitting on the left side of the fuselage exterior, just forward of the front entrance door. Refer to paragraph on Ballast Provisions For Engine Removal for further information.

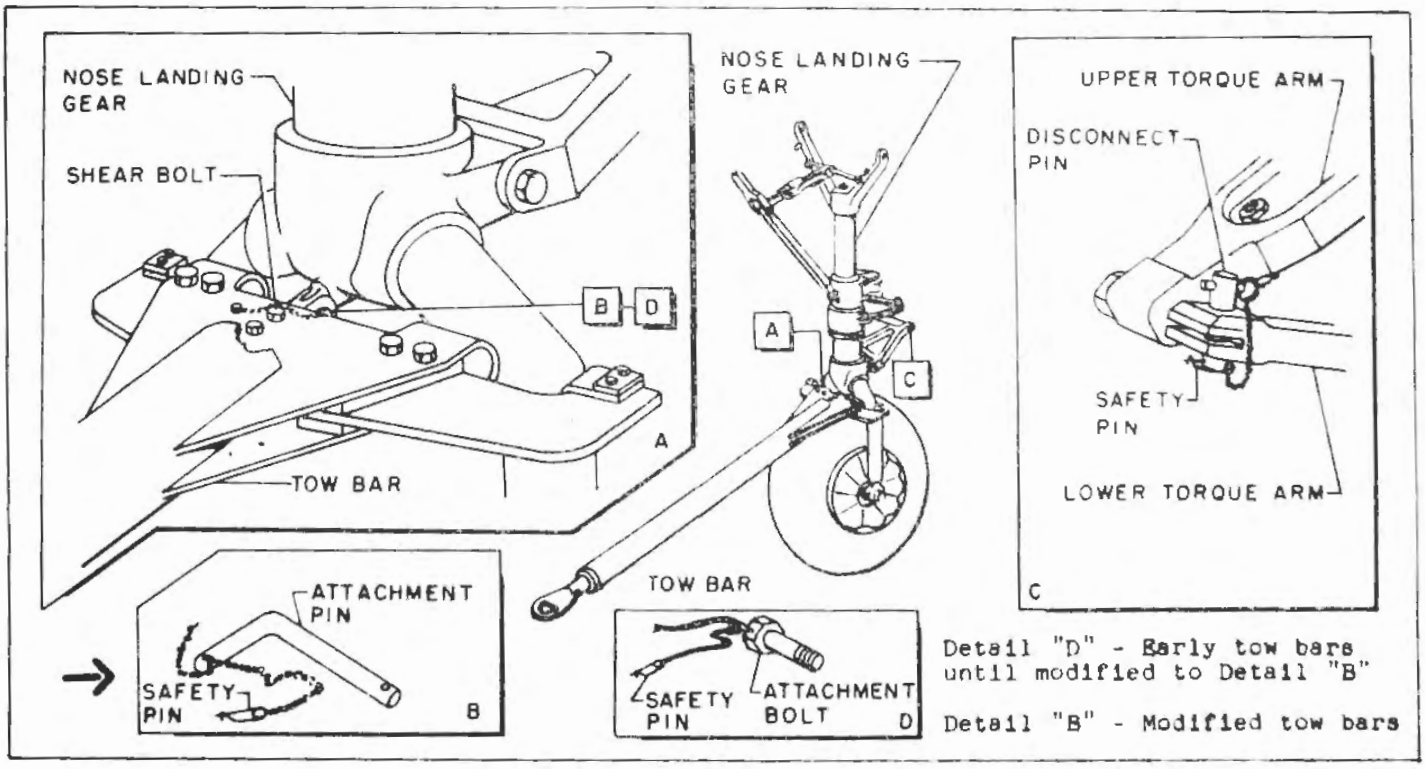


Figure 2. Tow Bar Installation

Towing Preparations - General Precautions.

Prior to any towing operation determine that the following steps have been accomplished.

1. Landing Gear Lock Pins are installed in the jury struts of all three landing gears.
2. All belly access doors are closed.
3. Passenger ramp up and locked.
4. Wing flaps retracted.
5. Forward entrance door closed (for safety of personnel aboard the airplane).
6. Control surfaces locked in neutral.
7. 1500 psi hydraulic pressure provided in closed center system for operation of brakes.
8. Nose gear torque arm disconnected, if towing from the nose gear.

Towing - General Precautions.

During all towing operations the following precautions should be observed.

1. A qualified man shall be stationed in the L.H. seat of the pilot's compartment to operate the brakes when necessary.
2. Allow more than normal clearance for all obstructions when towing the airplane forward, because when airplane brakes are applied the airplane may still move forward and then backwards up to 7 inches after main wheels stop as the damper drag strut compresses (due to inertia of the airplane) and then extends.
3. Use only the shear bolt or pin provided with the tow bar. Since the tow bar is designed to a strength approaching that of the nose gear, use of higher strength bolts or pins will endanger the airplane structure.
4. Station personnel at each wing tip and at tail if necessary, when towing in confined areas to signal clearance from obstructions.
5. When ballast is attached to side of airplane, extreme care must be used during towing operation so as to prevent ballast from swinging and damaging the airplane.

Ballast Provisions For Engine Removal - General.

When the airplane is on the gear in either the static or towing conditions, or when it is on jacks, with one or both engines removed, the center of gravity will be moved to a critical aft position. The aft center of gravity will be even more critical with personnel aboard the airplane with engines removed. To compensate for this, ballast must be added to the forward section of the fuselage. This ballast is added to a removable ballast fitting on the left side of the fuselage just forward of the front entrance door.

Ballast Requirements - Towing And Static. (See figure 3).

Provisions are incorporated on the left side of the fuselage at station 212 for the attachment of the removable ballast fitting. This fitting is installed by removing the four NAS 222 or 223 screws from the mounting holes; then attaching the fitting with four AN bolts with washers under the heads. The amount of ballast required on the fitting will vary depending on the number of engines removed. Refer to Series 3 of this chapter for ballast requirements.

A tail support stand must be installed at station 900 and must just clear the ground whenever one or both engines are removed. (When a tail post is not available, an engine may be changed by lowering and locking the ramp in the down position. All other requirements as to ballast and personnel aboard the plane must be complied with.) This tail support must be installed while the airplane is being towed or in a static condition. No personnel shall be permitted aft of fuselage station 460 (third row of seats) while towing with one or both engines removed. A limited number of personnel are permitted aft of this station when the airplane is in a static condition with one or both engines removed. Refer to Series 3 of this chapter for personnel permitted aft of station 460.

WARNING

The ballast attachment fitting must be removed and NAS 230 screws installed in the four mounting holes before flight.

The airplane may be jacked complete at the two wing jack points and the fuselage jack point with engines removed and the proper ballast added to the ballast fitting. A tail support must be installed after the airplane is jacked and removed before the jacks are lowered. While airplane is on jacks with engines removed and ballast installed, total weight of airplane, ballast and personnel must not exceed maximum jacking weight as specified in Series 3.

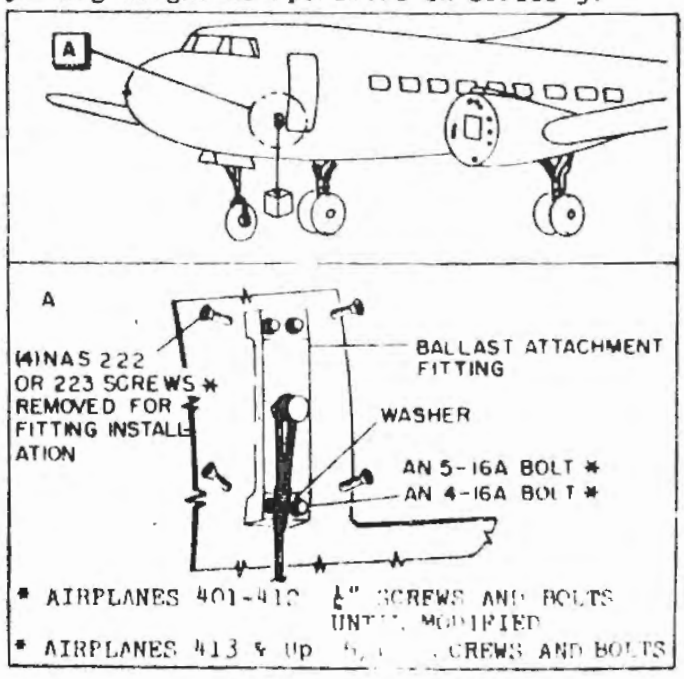

A
A
(4)NAS 222 OR 223 SCREWS * REMOVED FOR FITTING INSTALLATION
BALLAST ATTACHMENT FITTING
WASHER
AN 5-16A BOLT *
AN 4-16A BOLT *
* AIRPLANES 401-412 ⅝" SCREWS AND BOLTS UNTIL MODIFIED
* AIRPLANES 413 & UP ⅝" SCREWS AND BOLTS

Figure 3. Ballast Attachment Fitting

Leveling (See figure 4).

The airplane can be checked for level by placing a spirit level across the lateral and longitudinal leveling lugs located in the bottom of the fuselage, and which are accessible through the belly electrical hatch between stations 389.5 and 411. To level the airplane, first install jacks at each of the wing jack points and at the fuselage jack point, then place a spirit level across leveling lugs (1) and (2) at station 389.5 (surface "A"). Raise or lower wing jacks as required until airplane is level laterally. Place the spirit level across leveling lug (3) at station 411 and leveling lug (4) at station 389.5 (surface "B"). Raise or lower fuselage jack as required until airplane is level longitudinally. Recheck lateral level after leveling longitudinally and correct if necessary. Refer to section on jacking of this chapter for information on use of jacks.

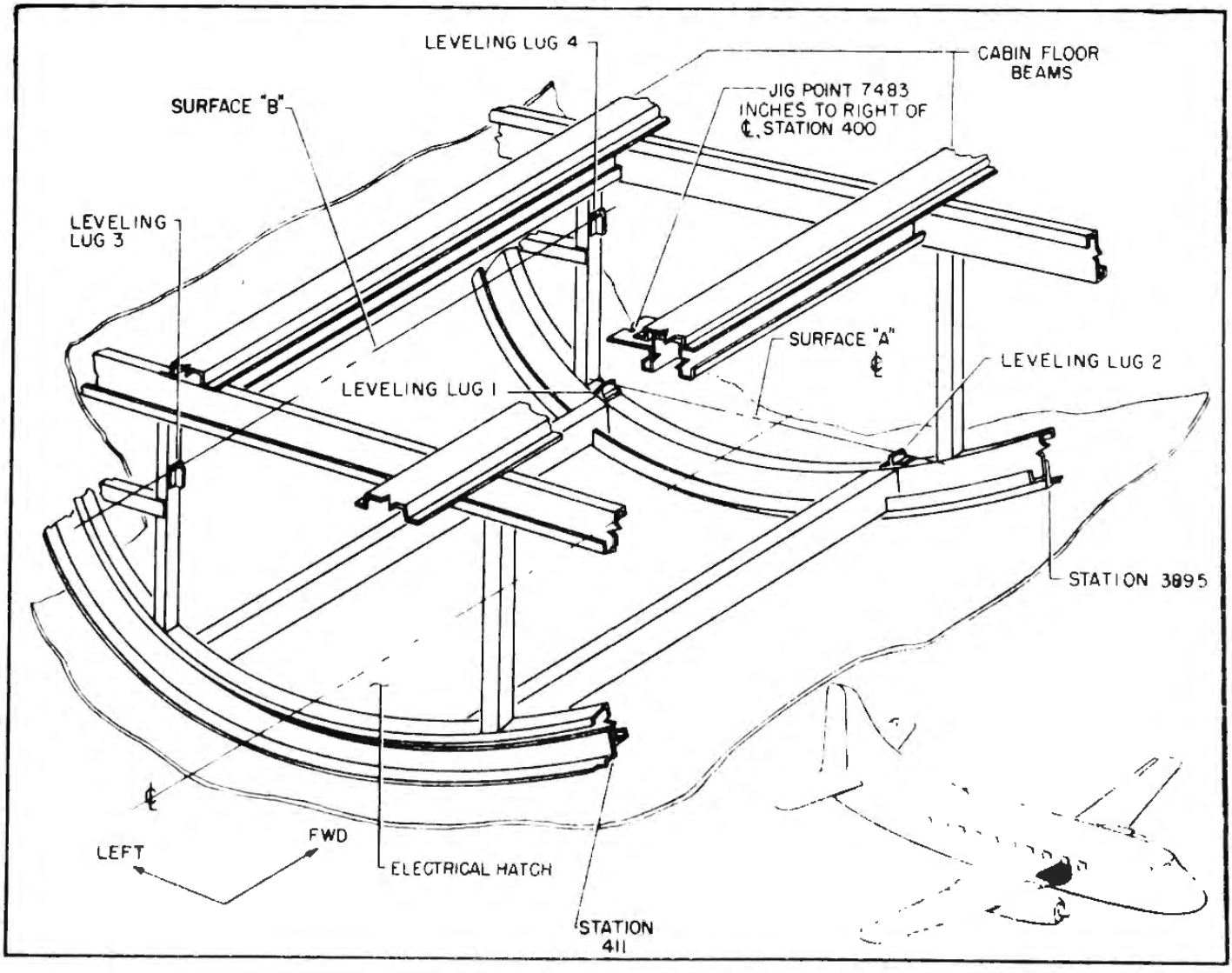


Figure 4. Leveling Provisions

JACKING PROVISIONS - GENERAL (See figure 16).

The airplane may be jacked complete from three points. A single jack point is located on the lower surface of the forward section of the fuselage at station 212 on the right side of the center line of the airplane. Two other jack points are located on the lower surface of the center wing, one on each side at wing station 120, on the flap hinge fitting immediately inboard of each nacelle and directly below the rear spar. A fitting for attaching a tail support is located on the lower surface of the fuselage aft of the entrance ramp at station 900. The tail support is used to prevent over balancing (tail tipping) of the airplane. Integral jack pads are incorporated on each main gear and a removable jack pad is provided for the nose gear, so that any one gear may be jacked indiyidually. Refer to Maintenance Notes of this chapter for information on capacity and size of jacks required for this airplane.

Jacking Precautions And Limitations.

1. Do not jack the airplane when its gross weight exceeds 36,000 pounds. The airplane weighs approximately 32,000 pounds empty without fuel, cargo, baggage, or personnel aboard. Refer to WEIGHT LIMITS FOR JACKING in maintenance notes of this chapter for permissible weights at the various jack points.

2. Landing Gear Lock Pins must be installed in the jury struts of all gears while raiseing or lowering the airplane at the wing and fuselage jack points. If jacking on the gears, the main gear jacking lock pins must also be installed in the main gear drag strut dampers.

3. Have stands and equipment clear of the airplane.

4. If jacking outside, head airplane into the wind. Do not jack airplane under gusty or excessive windy conditions.

5. Remove chocks from wheels and release parking brakes.

6. Raise all three jacks evenly to keep airplane level.

7. Adjust locking devices on jacks to prevent accidental lowering.

8. Attach a tail support to fitting on fuselage at station 900 after airplane is jacked complete. This tail support must be off during jacking and lowering operations, and is installed only for better stability after airplane is on or off jacks.

9. When necessary to jack the airplane from a single point, keep lift to an absolute minimum, and always within safe limits of jack and jack points.

10. Do not jack more than one gear at a time, assuring other wheels are chocked during the jacking operation and while on jacks.

11. Determine that a jack of sufficient capacity is used. (See "Maintenance Notes 1-3 for capacity recommendations of jacks).

Jacking For Servicing Nose Gear Wheel. (See figure 5).

The nose gear wheel may be serviced by jacking at either the fuselage jack point at station 212 (refer to JACKING PROVISIONS - GENERAL), or at the nose gear strut. To jack at the nose gear strut, a removable jack pad is installed on either side of the nose gear fork to accommodate a jack. If the nose wheel assembly is to be removed, a fork retainer is installed on the other side of the nose gear fork to prevent the fork from spreading (refer to Chapter 15 for details of its use). Two pins, one 3/8 inch and one ½ inch, are secured by means of chains to the removable jack pad. The 3/8 pin is used to attach the jack pad to the nose gear fork, while the ½ inch pin is inserted in the hole in the rear of the nose gear strut and the turning collar to lock the steering.

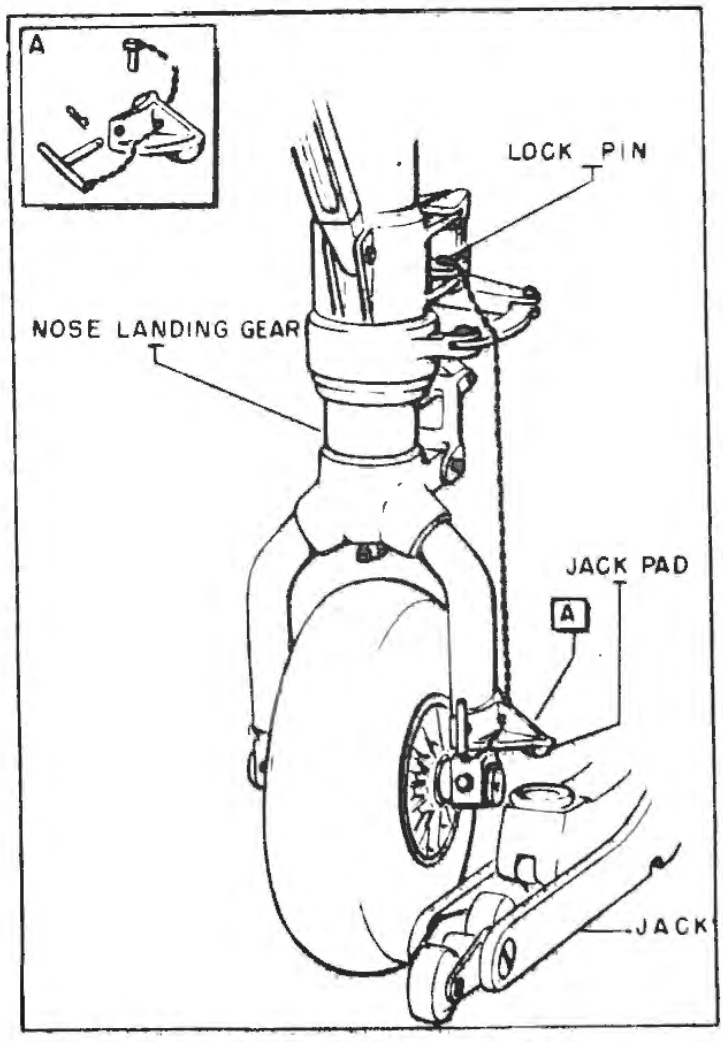


Figure 5, Nose Gear Jacking

Jacking For Servicing Nose Gear Wheel (Cont.).

CAUTION

Prior to jacking, connect torque arm on nose gear strut, and disengage the rear ramp actuating struts from the ramp down lock to prevent damage to the ramp as the tail of the airplane is lowered during the jacking operation. Also, determine that steer lock pin is inserted in turning collar to prevent nose wheel from turning and jumping off the jack.

As an added safety precaution to prevent tail tipping, install an adjustable tail support stand to the fitting on the fuselage at station 900 after the nose gear is jacked. This tail support when attached to the fuselage fitting, should be just clear of the ground.

Jacking For Servicing Main Gear Wheels And Brakes. (See figure 6).

The main gear wheels and brakes may be serviced by jacking at either main gear. A jack pad is built integral in the bottom of the main gear shock strut to accommodate a jack. When jacking at either main gear, a jacking lock pin (404-4900171) must be installed in the drag strut damper of the gear being jacked to prevent it from extending. Also, the wheels of the other main gear must be chocked fore and aft. To install the jacking lock pin, first remove the ¼ inch bolt attaching the upper end of the spring bungee to the drag strut damper and allow bungee to hang down from the attachment at the other end; then install the jacking lock pin in the drag strut damper by inserting it in a hole in the crotch of the damper and tightening it. With the drag strut damper in the retracted position, the bungee can be disconnected and connected without special tools.

CAUTION

After jacking operation, be sure that jacking lock pin is removed and that bungee is again connected to the drag strut damper with the ¼ inch bolt and safetied.

In the event that a jack is not available, one of the wheels may be rolled by engine power up a ramp of very slight incline until the other wheel clears the ground.

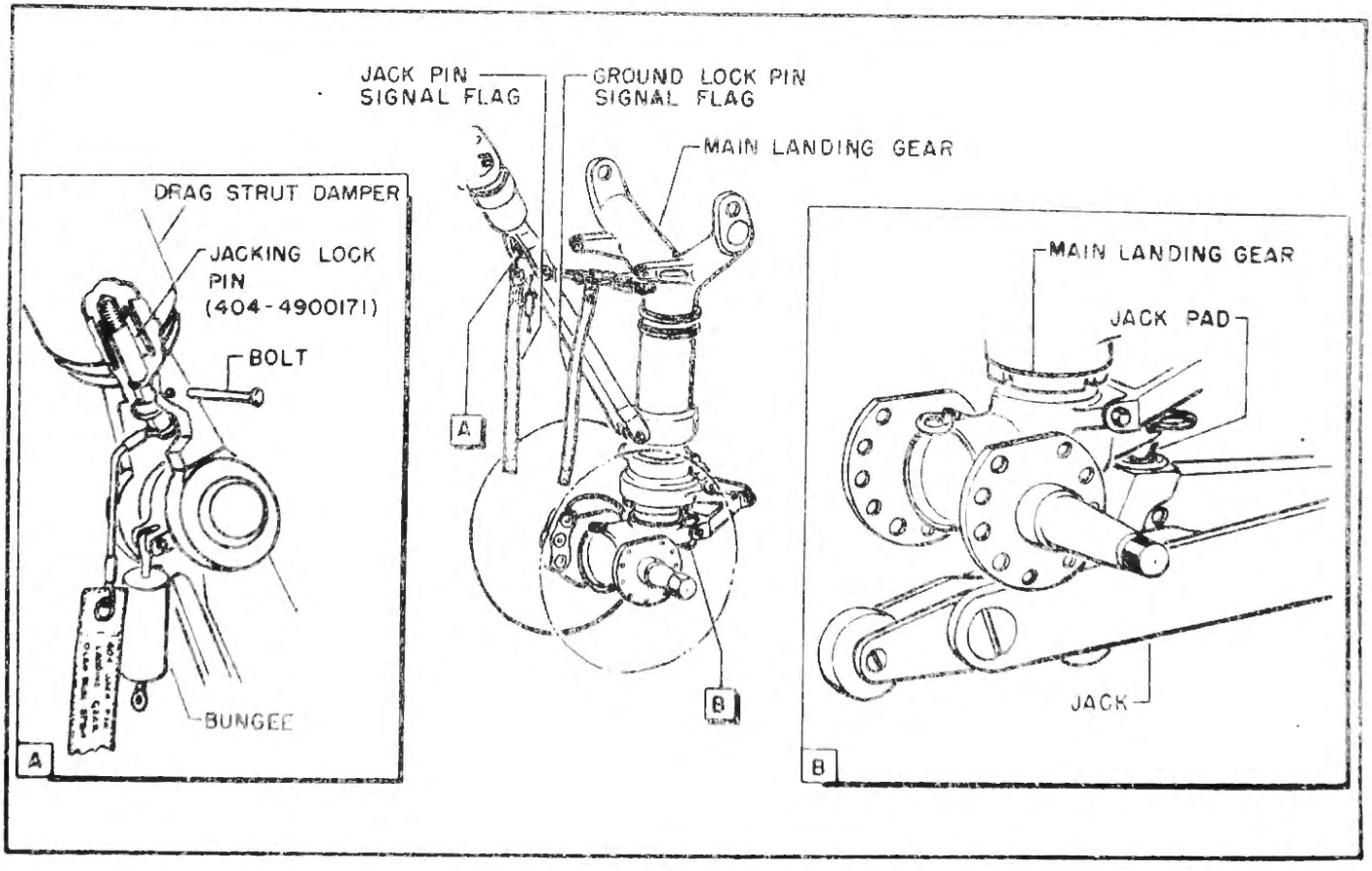


Figure 6. Main Gear Jacking

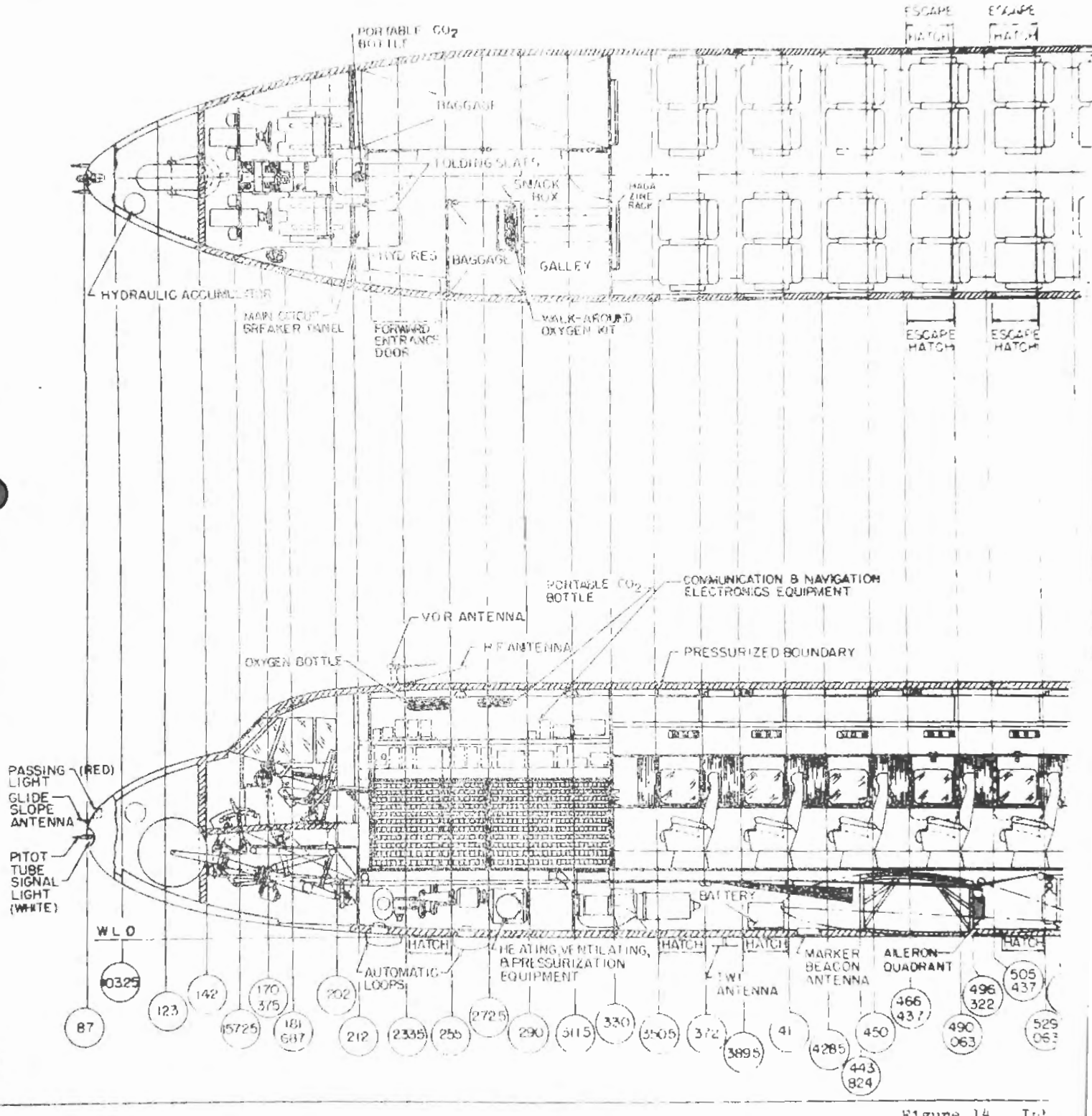
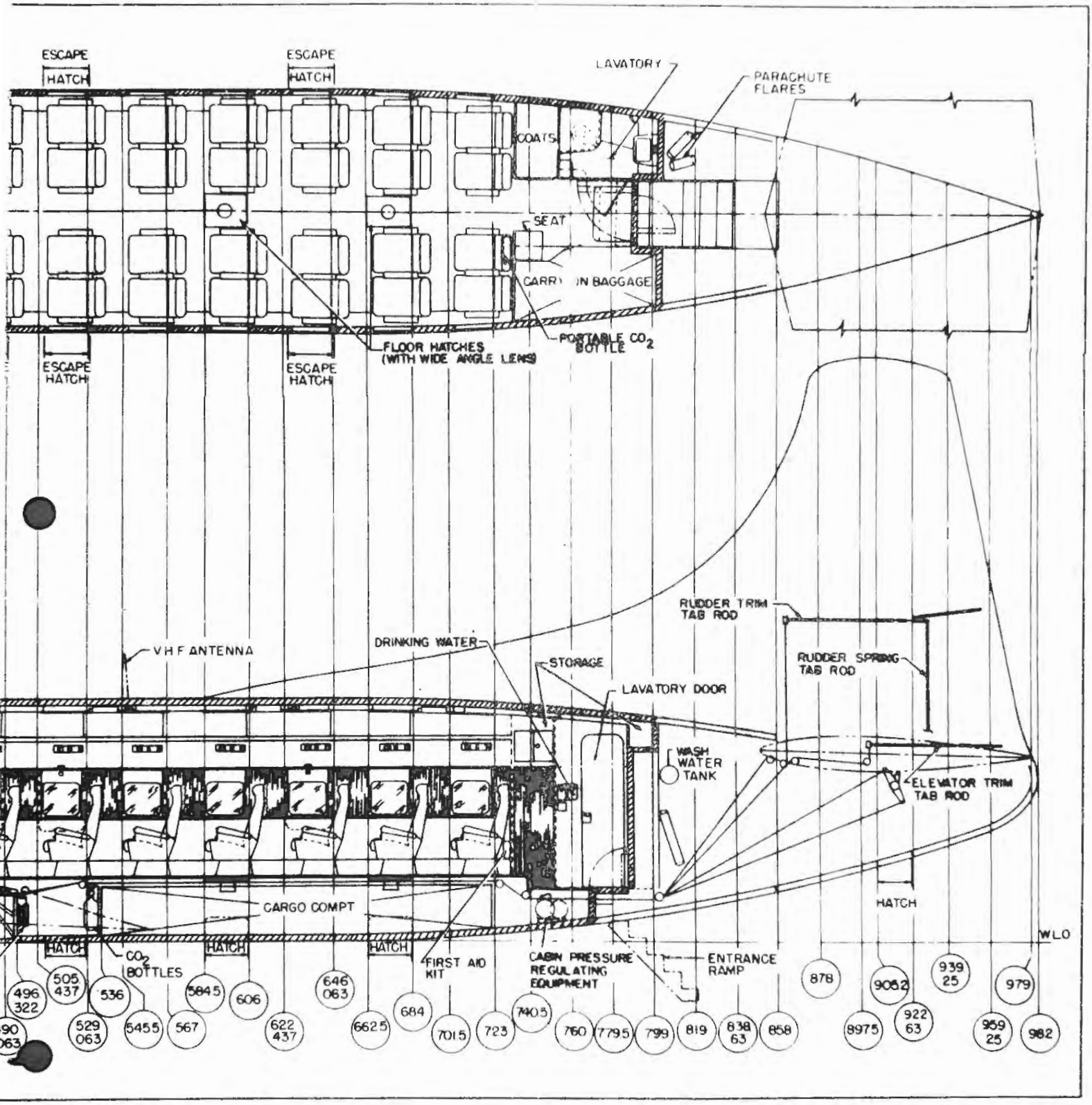
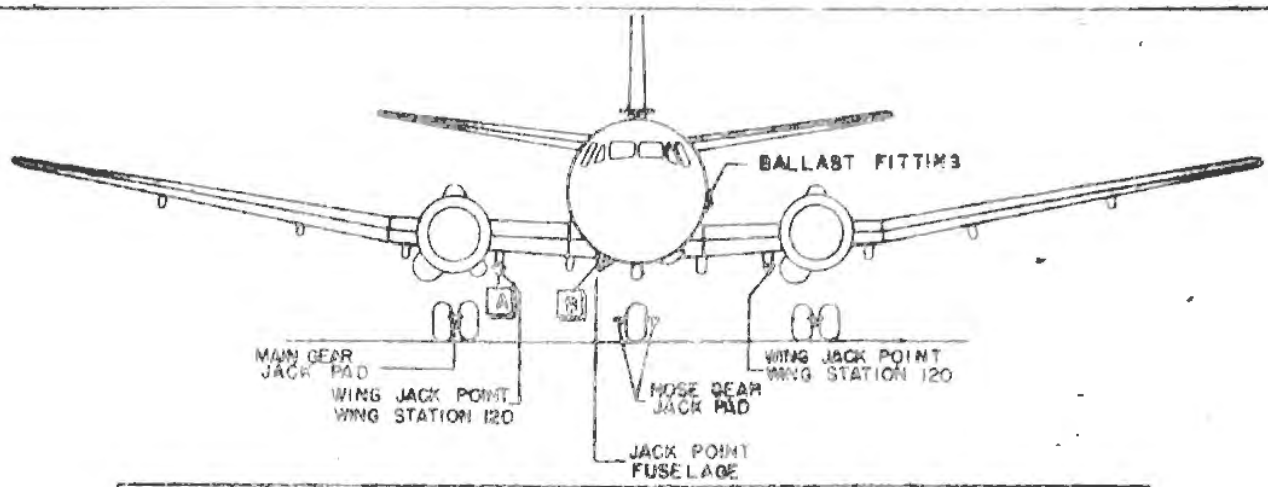


Figure 14. Int

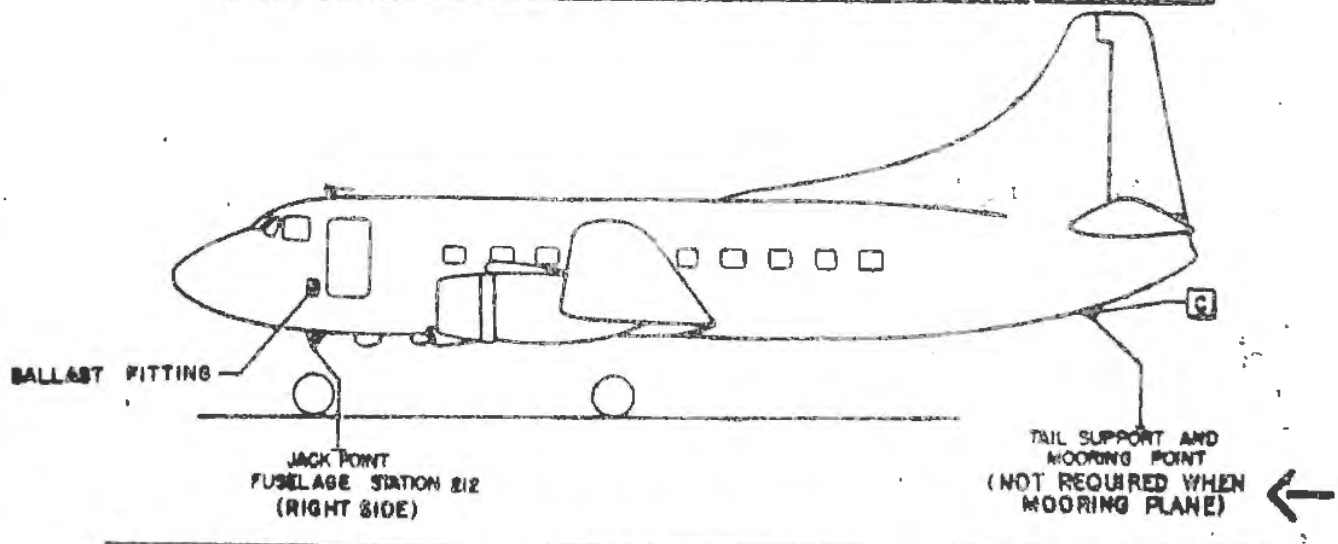


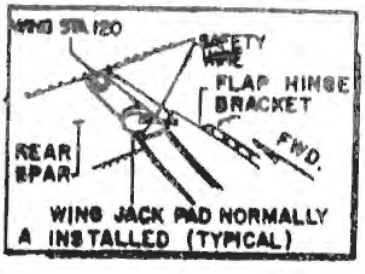
e 14. Inboard Profile

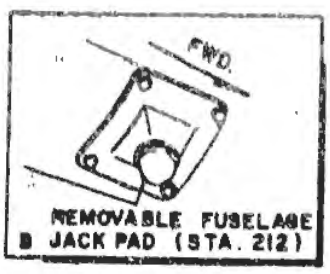


CONDITION	WING JACK POINT WING STATION 120	NOSE GEAR JACK PAD	MAIN GEAR JACK PAD	DISTANCE TO JACK POINT FUSELAGE STATION 212
ALL TIRES FLAT, OLEOS COMPRESSED	58 3/8			64 15/16
MAIN AND NOSE GEAR OLEOS EXTENDED TIRES FULLY GROWN	81 3/4			85 3/8
MAIN AND NOSE GEAR EXTENDED TIRES FULLY GROWN+2-IN CLEARANCE	83 3/8			87 3/8
MAIN AND NOSE GEAR TIRE FLAT, OLEOS STATIC	62 3/8			72 15/16
NOSE GEAR TIRE FLAT, OLEO STATIC, MAIN GEAR TIRE FLAT, OLEO COMPRESSED	58 3/4			72 7/8
FLAT TIRE		12 1/13	8 3/4	
TIRE FULLY GROWN+2-INCH CLEARANCE		21	20 3/13	

NOTE: ALL MEASUREMENTS TAKEN FROM GROUND LINE AND GIVEN IN INCHES


BALLAST FITTING
JACK POINT FUSELAGE STATION 212 (RIGHT SIDE)
TAIL SUPPORT AND MOORING POINT (NOT REQUIRED WHEN MOORING PLANE)
C





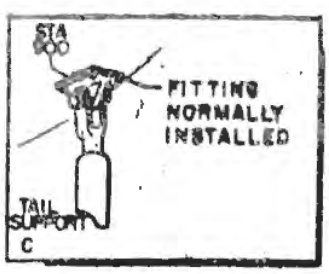


Figure 16. Jacking Diagram

BALLAST REQUIREMENTS FOR ENGINE REMOVAL.

Towing.

The following amounts of ballast are required on the removable ballast fitting at Station 212 while towing with one or both engines removed, and tail support installed just clear of the ground. This ballast is required to hold the airplane center of gravity at Station 460 (12.7" forward of the main gear axle). Care must be exercised when towing during gusty or windy conditions. Towing condition is based on maximum tow bar load of 6620 pounds.

Engines Removed	Personnel Permitted Aft of Station 460	Ballast Requirements
1	None	1020 pounds
2	None	3300 pounds

Static.

The following is the ballast requirements for engine removal and number of personnel permitted aft of the center of gravity with the tail support installed just clear of ground and airplane in static condition. These figures are based on the center of gravity being at its most aft point at Station 470 (2.7" forward of main gear axle).

Engines Removed	Ballast Required	Personnel On Stabilizer	Personnel Aft of Ramp	Personnel Between Sta. 470 and Ramp	Total Personnel Aft of Sta. 470
1	3300 pounds	2	1	26	29
2	3300 pounds	2	1	13	16

When a tail post is not available, an engine may be changed by lowering and locking the ramp in the down position. All other requirements as to ballast and personnel aboard the plane must be complied with.

WEIGHT LIMITS FOR JACKING.

The airplane must not be jacked when its gross weight exceeds 36,000 pounds. The airplane weight empty (without fuel, cargo, baggage, or personnel aboard) is approximately 32,000 pounds. Refer to the airplane operation record for exact empty weight.

The following chart lists the maximum weights permissible at the various jack points. The "MAXIMUM STATIC LOAD" is the maximum weight permissible at a jack point, while the "MAXIMUM LOAD CAPACITY" is the maximum weight permissible with the load factor included which might result from a jack slipping slightly and the airplane dropping on the jack point or the jack not being placed exactly perpendicular to the jack point.

JACK POINT	FUSELAGE STATION	WING STATION	MAXIMUM STATIC LOAD	MAXIMUM LOAD CAPACITY
Center Wing	492.2	120	15,900 (each)	31,800 (each)
Fwd. Fuselage	212	---	7,350	14,700
Main Gear	---	150	17,400 (each)	23,200 (each)
Nose Gear	205	---	5,080	6,770
Tail Support	900	---	---	6,000

When jacking the entire airplane, the plane shall be empty and not more than 650 gallons of fuel aboard. Otherwise, the load at the wing jack point will exceed the "MAXIMUM STATIC LOAD" specified in the chart.

When jacking at only one wing jack point, a corresponding maximum load condition shall be observed before jacking.

JACKING PRECAUTIONS.

1. Engine removal with ballast, as shown above, shall not be done with airplane on nose gear jack.
2. Airplane shall not be raised or lowered on structural jacking points with engines and ballast both installed.

JACKS.

Nose Gear - 12 ton or more capacity with a closed height of 48 inches or less and an extended height of 98 inches or more.
Main Gear - 17 ton or more capacity, with a closed height of 48 inches or less and an extended height of 98 inches or more.

Nose Steering - 50° each side of neutral (Torque arm connected)
Nose Gear Towing - 6620 pounds maximum tow load on strut
Main Gear Towing - 6620 pounds maximum tow load on strut

General

The instructions and procedures which follow shall be used by maintenance personnel as a guide in checking an aircraft which has been subjected to severe turbulence in flight or to an abnormally hard landing. The critical areas to be checked on the aircraft are outlined in the descriptions and diagrams provided in the following pages.

When an airplane is reported as having been subjected to severe turbulence or a hard landing, a detailed check (Part C or D) of the aircraft structure must be made. However, there are situations when it is not practical tomake the detailed check immediately. If in accordance with the policy established by the General Policy and Procedure Manual, the Airworthy check (Part B) may be made and if the aircraft is found airworthy it may continue to another station for the detailed check.

Airworthy Check

1. (Hard landing only) Check nose gear assembly and gear attachment forgings for any indication of damage.

2. (Hard landing only) Check main gear assemblies and gear attachment forgings for any indication of damage.

3. Check nacelle fillets for wrinkles or distortion.

4. Check nacelle longitudinal members and attachments for distortion.

5. Check wing skin, top and bottom, for wrinkles or permanent set.

6. Check leading edge skin between the nacelles for wrinkles or distorition.

7. Check exterior or empennage and fuselage, particularly on upper surface of stabilizer where fuselage skin attaches to front beam of stabilizer.

8. Check exterior of wings for fuel leaks.

   a. If no damage is noted during the check, an entry shall be made in the M-76 aircraft log stating that a check was made and no damage was found. The entry shall be signed for by the personnel making the check. The aircraft may then be released to complete the flight.

   b. MCIMD shall be advised by teletype message that a detailed check will be required. A copy of the message shall be sent to the terminating station.

   c. If structural damage is found during an airworthy check, the Maintenance Foreman or DPSM shall be advised for their further handling with MCIMD.

Detailed Check

Flight Turbulence (See Figure 1)

The illustration included with the detailed check procedure for the aircraft indicate the high stress areas where damage is most likely to occur; however, it is not intended to imply that failure or distortion will occur only at these points. The structural check should cover all areas in general.

A thorough check of all the areas listed below shall be made on any Martin 404 aircraft which has been operated through severe turbulence during flight. In the event that damage is discovered in any of the areas listed, the check must be extended to adjacent load carrying structure. The approximate location of each check area described is indicated by the corresponding item number on the illustrations.

1. Examine fuselage crown skin and stringers between pressure bulkhead 799 and bulkhead 858 for distortion.

Detailed Check (Cont.)

2. In the event of violent yaw correction maneuver, examine:

   a. Fuselage side and bottom skin, stringers and riveting in area between aft end of ramp and station 905.

   b. Interconnect pin and adjacent structure at leading edge of fin and dorsal fin.

3. Check lower diagonal tube of engine mount for bowing or buckling at center and at aft end.

4. Check aft end of lower nacelle longeron for buckling (in lower nacelle tail cone).

5. Check engine mount fitting back-up structure and nacelle side skin and riveting between firewall and wing front spar with particular attention to cut-out.

6. Check wing bottom cover attachment to front and rear spars from wing station 55 to nacelle.

7. Examine wing bottom skin and attachments, station 187 to 220.

8. Examine wing bottom skin attachment to rear spar stations 430 to 472.

9. Examine wing top cover outer skin for loose rivets or inter rivet buckling at station 55 (with wing fillet removed) and at stations 187, 272.5, 342, 413 and 472.

10. Examine riveting of wing top cover and wing leading edge in vicinity of nose rib and front spar, station 187.

11. Examine wing rear spar web, stations 272 to 343.

12. All fuel tank areas should be closely checked for evidence of fresh fuel leaks, since the structure may have been damaged, but a fuel stain may not have had time to develop.

13. Upon completion of the check, a "Hard Landing Flight Turbulence Structural Check" form MCI9-275A shall be completed by the personnel making the check and forwarded to the Director of Flight Test and Inspection, MCI.

Detailed Check

Hard Landing (See Figure 2)

The illustration included with the detailed check procedure for the aircraft indicated the high stress areas where damage is most likely to occur; however, it is not intended to imply that failure or distortion will occur only at these location points. The structure check should cover all areas in general.

A thorough check of all the areas listed below shall be made on any Martin 404 aircraft which has been subjected to an abnormally hard landing. In the event that damage is discovered in any of the areas listed, the check must be extended to adjacent load carrying structure. The approximate location of each check area described is indicated by the corresponding item number on the illustrations.

1. Examine lower exterior of fuselage between stations 505.3 and 529.3 for distortion of wing fillet fairing either side of access door.

2. Examine lower exterior of fuselage between stations 411 and 433 for distortion of wing fillet fairing. Also examine skin and stringers forward to station 350.

3. For hard landings with brakes locked or severely braked landings, examine fuselage upper skin and stringers forward and aft of station 443.

4. Examine fuselage side skin between top of windows and top of wing fillet between fuselage stations 411 and 645.

5. In event of severely yawed or hard one wheel braked landing or hard landing on nose gear, examine:

   a. Horizontal shelf between nose wheel trunnion fitting.

   b. Web and riveting in vertical nose wheel beams between nose wheel trunnion station and bulkhead 212.

   c. Chords, web and riveting of bulkhead 212 below cabin floor level.

Detailed Check (Cont.)

5. (Cont.)

   d. Chords, web and riveting of bulkhead 142 below pilot's floor.

   e. Chords, wet, riveting and bolts of drag link beam.

6. Examine main landing gear support trusses including drag strut fitting, chords, web and riveting of canted beams which are upper members of main landing gear trusses. Check wing rear spar web and riveting inboard of station 135.

7. Chec, main and nose gear tires for bald spots, blisters and pressure.

8. Check wing rib 120 in area of forward diagonal bottom attachment.

9. Check wing bottom cover attachment to front and rear spars from wing station 55 to nacelle.

10. For severe lateral drift landings, check riveting of shear shelf between main landing gear spreader bar and rear spar with lower aft nacelle tail cone removed.

11. Check lower diagonal tube of engine mount for bowing or buckling at center and at aft end.

12. Check aft end of lower nacelle longeron for buckling (in lower nacelle tail cone).

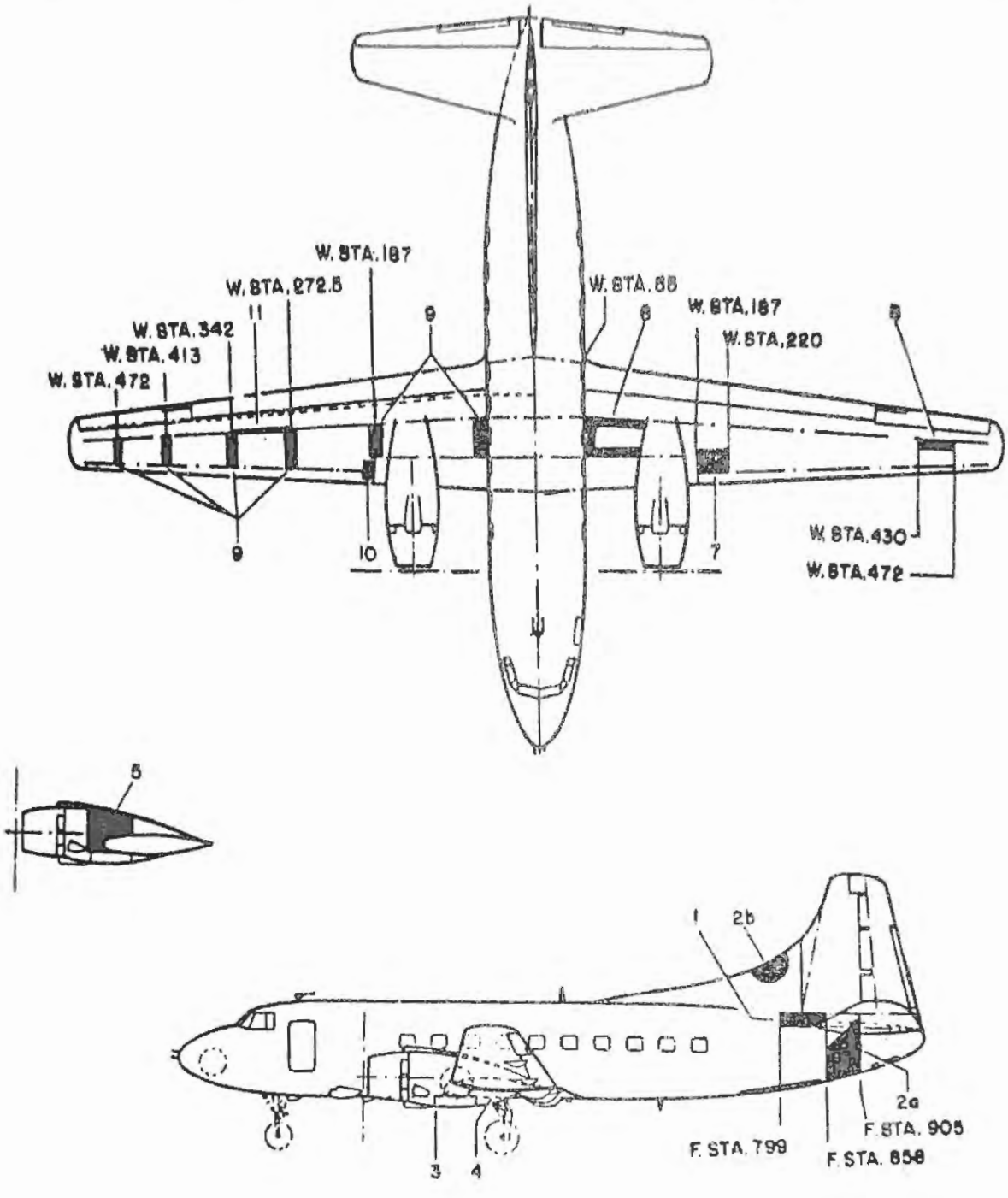
13. Check engine mount fitting back-up structure and nacelle side skin and riveting between firewall and wing front spar with particular attention to cut-out.

14. Examine main landing gear strut and oleo drag strut at points of discontinuity for obvious signs of cracking or distortion.

15. With upper fairing removed, examine most aft six inches of upper and lower wing top cover splice angles at station 187.

16. All fuel tank areas should be closely checked for evidence of fresh fuel leaks, since the structure may have been damaged, but a fuel stain may not have had time to develop.

17. Upon completion of the check, a "Hard Landing/Flight Turbulence Structural Check" form M-139-275A shall be completed by the personnel making the check and forwarded to the Director of Flight Test and Inspection, MCI.


W. STA. 187
W. STA. 272.5
W. STA. 342
W. STA. 413
W. STA. 472
11
9
W. STA. 88
8
W. STA. 167
W. STA. 220
5
9
10
7
W. STA. 430
W. STA. 472
5
1
2b
2a
F. STA. 905
F. STA. 799
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3
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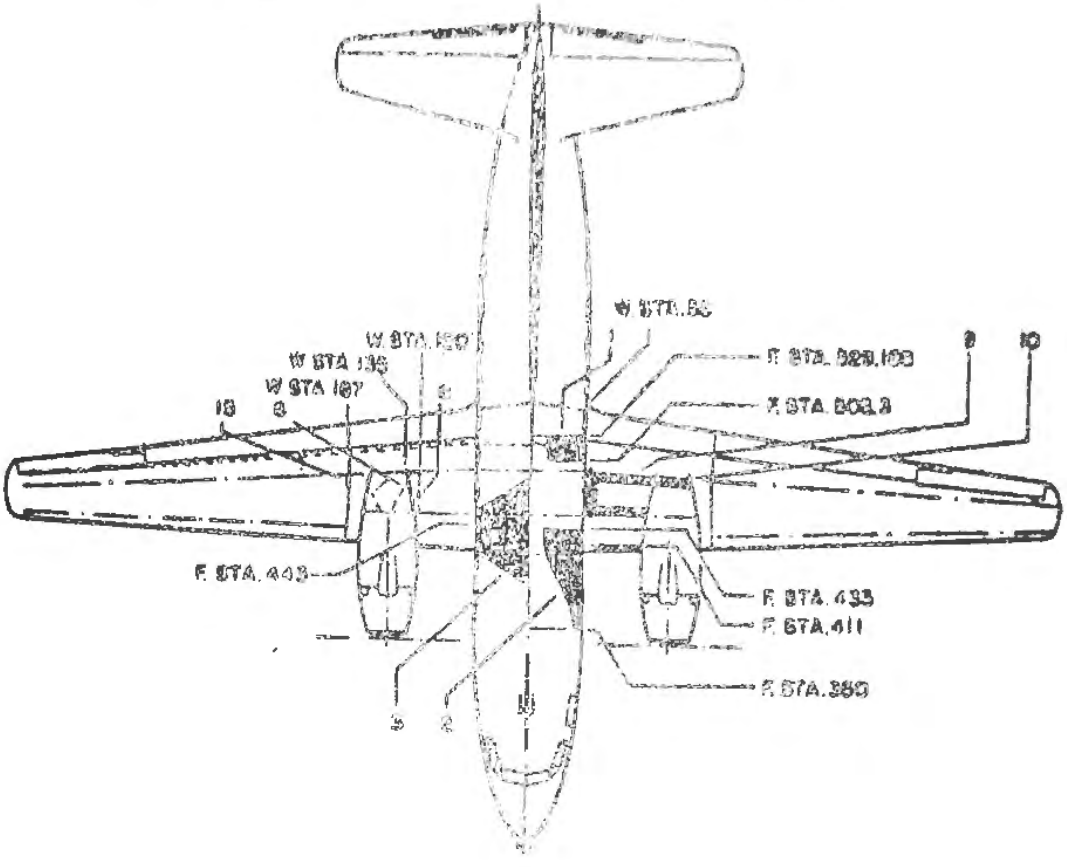
FIGURE 1


W STA. 80
W STA. 120
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X STA. 503.3
F STA. 443
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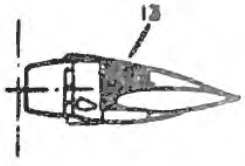

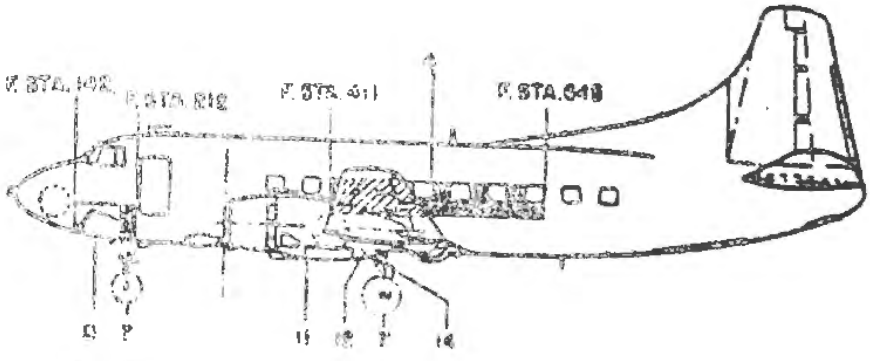
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FIGURE 2

1. The gust locks must be engaged on aircraft parked outside the hangar.

2. The following checks shall be made if aircraft are parked outside the hangar and subjected to buffeting when gust locks have not been engaged for any reason.

   a. Check for damage of the tripod frame, or its attachments, which supports the bearing at the lower end of the torque tube assembly.

   b. Check for cracks in the cast arm which attaches at the lower end of the torque tube. Cracks may occur in the area of the two attachment bolts.

   c. Check the torque tube for cracks in the area directly below the upper flange attachment.

   d. Check for evidence of sheared rivets in the upper flange to tube attachment while hard pressure is applied to rudder pedals with Gust lock engaged.

   e. Check the rudder structure in the area of the torque tube flange and the rudder hinges.

   f. Check rudder stops for damage.

   g. Check rudder hinges and hinge cutouts for damage.

ILLUSTRATIONS OF PROPELLER OPERATION

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FUSELAGE - GENERAL (See figure 1).

The 4-0-4 fuselage is of all metal, semi-monocoque construction, consisting of bulkheads, frames and formed longitudinal stringers covered with aluminum alloy skin. The fuselage is compartmented into several sections consisting of a pilots' compartment, a radio, galley and baggage compartment, a passenger compartment, an aft fuselage section, a nose wheel well, and equipment and cargo sections in the belly of the fuselage.

Construction and sealing of the fuselage is such that a pressure differential of approximately 3 psi can be maintained to provide passenger and crew comfort during high altitude flights. All skin splices in the entire fuselage area from the forward bulkhead at station 142 to the aft cabin bulkhead at station 799 are sealed to withstand this pressure. All doors and hatches, and all openings for the control and actuating cables in the pressure boundry area are provided with seals to prevent leakage of cabin pressure.

The main fuselage station lines are shown in Figure 2, and the main water (W.L.) and butt lines (B.L.) are shown in Figure 1. These station, water and butt lines are measured in inches and are used in locating the various components in the fuselage. The station lines start with station 87 at the forward end and extend aft to the tail cone at station 982. The water lines start with water line "0" at the bottom of the fuselage and are plus above this line and minus below. The butt lines are measured to the right or left from the fuselage center line.

Fuselage Structure.

The fuselage structure consists of a forward fuselage section, a center fuselage section and an aft fuselage section. These sections are riveted and bolt spliced together. The center wing section is also an integral part of the fuselage and is attached to the fuselage through a riveted and bolted manufacturing splice.

The fuselage is composed of formed "Z" shaped stringers, formed frames, intercostal frames, bulkheads, stressed floor, and stressed skin. Primary formed stringers extend from the nose to the tail. Two heavy extruded frames, one over the front spar and one over the rear spar, take up the load transmitted from the wing. Nose gear impact loads are dissipated by truss and beam assemblies through the nose structure.

All sections of the fuselage structure and their splices are so constructed and sealed as to minimize water leakage when flying in rain or snow or standing on the ground in both pressurized and unpressurized conditions.

Ice shields are attached to both sides of the fuselage to prevent ice thrown from the propellers from damaging the fuselage. Refer to section on Fuselage Ice Shields for further information.

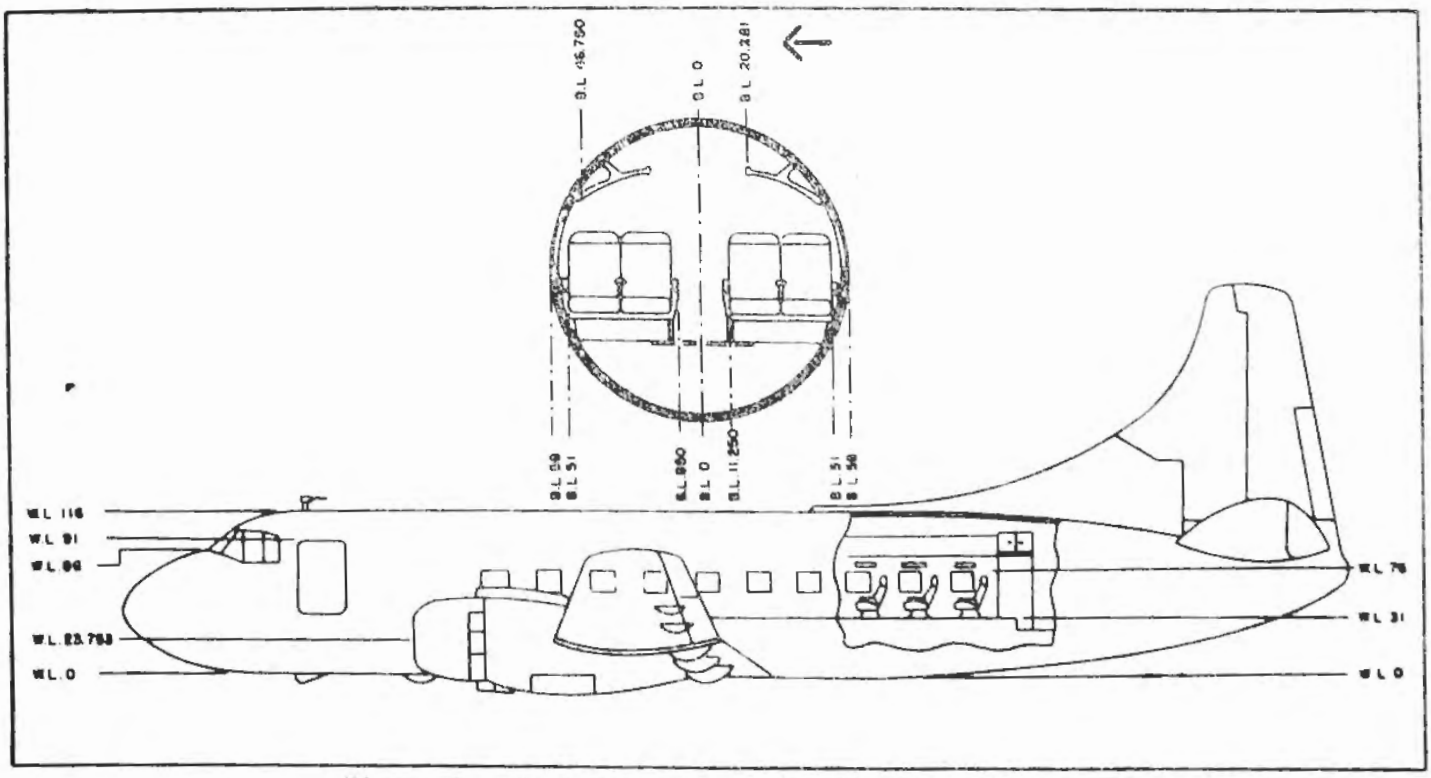


Figure 1. Fuselage Water and Butt Lines Diagram

Fuselage Wing Fillets

Removable wing fillets are used to fair the center wing in with the fuselage. Refer to Chapter 6 for further information and the replacement procedure.

Fuselage Sealing

Refer to Chapter 22 for applicable process on sealing of fuselage seams and joints to prevent water or air leakage while flying through rain or snow or standing on the ground in both pressurized and impressurized conditions.

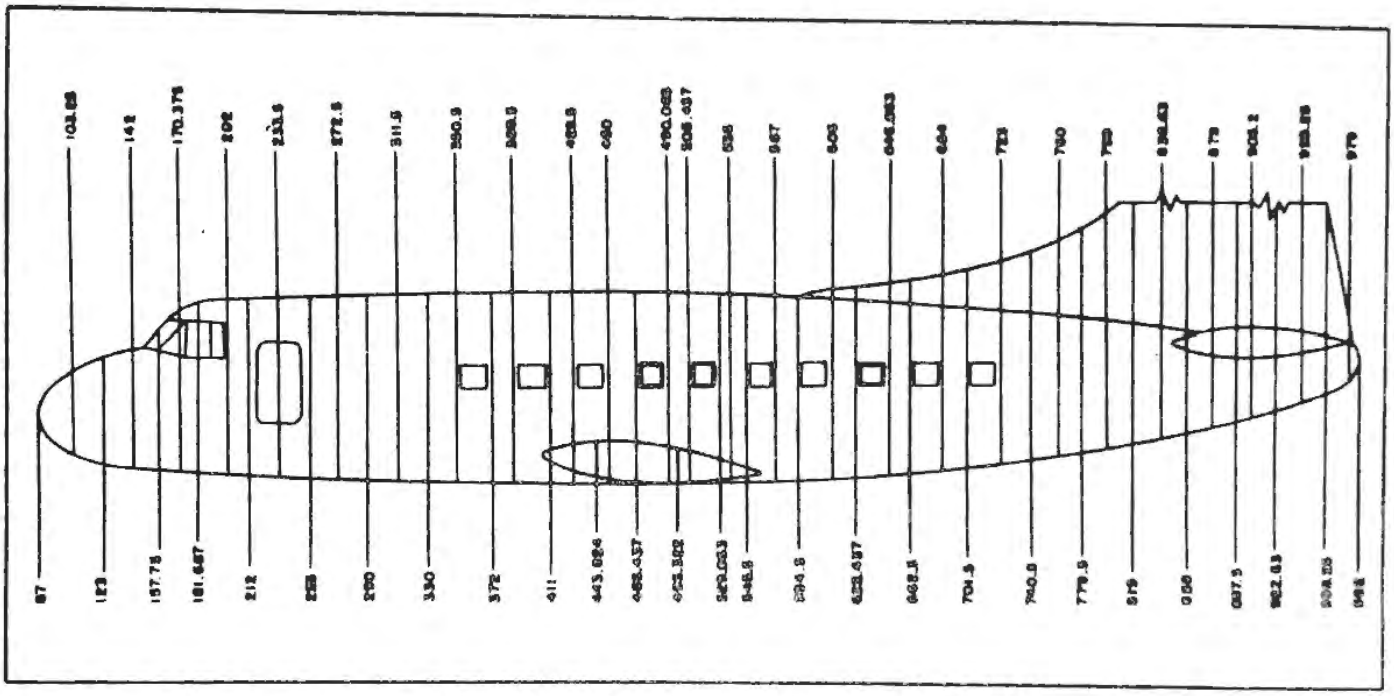


Figure 2. Fuselage Station Diagram

Fuselage Floor Panels (See figure 4).

The floor panels of the galley, radio, baggage and passenger compartments are constructed of honeycomb material and are attached to the floor frames and sills with either rivets or screws. The panels are reinforced on the top, bottom and edges with aluminum alloy sheet.

The floor panels in the galley, radio and baggage compartment are installed with screws and are removable. The entire flooring in this compartment, with the exception of the area directly beneath the galley, is covered with a hard surface covering which is attached to the top surface of the honeycomb floor panels with screws.

The removable floor panels in the passenger compartment consist of the center aisle panels and the side panels above the center wing between stations 428 and 545. These panels are installed with screws. The remaining panels in this compartment are riveted in place. Inserts are located in the floor panels at stations 371 and 410 left and right side at approximately the center of the passenger seats to permit installation of the cargo tie-down rings.

The panels in the center aisle at stations 584 and 662 are installed with quick-acting stud fasteners which permit easy access to the belly cargo compartment. These two panels are sealed on all sides when installed and latched. A wide angle viewing lens is installed in each of these panels under the carpet to permit looking into the belly cargo compartment during flight without having to remove the panels.

The floor panels in the passenger compartment are covered with wool carpet which is fastened to the floor with double surface adhesive tape.

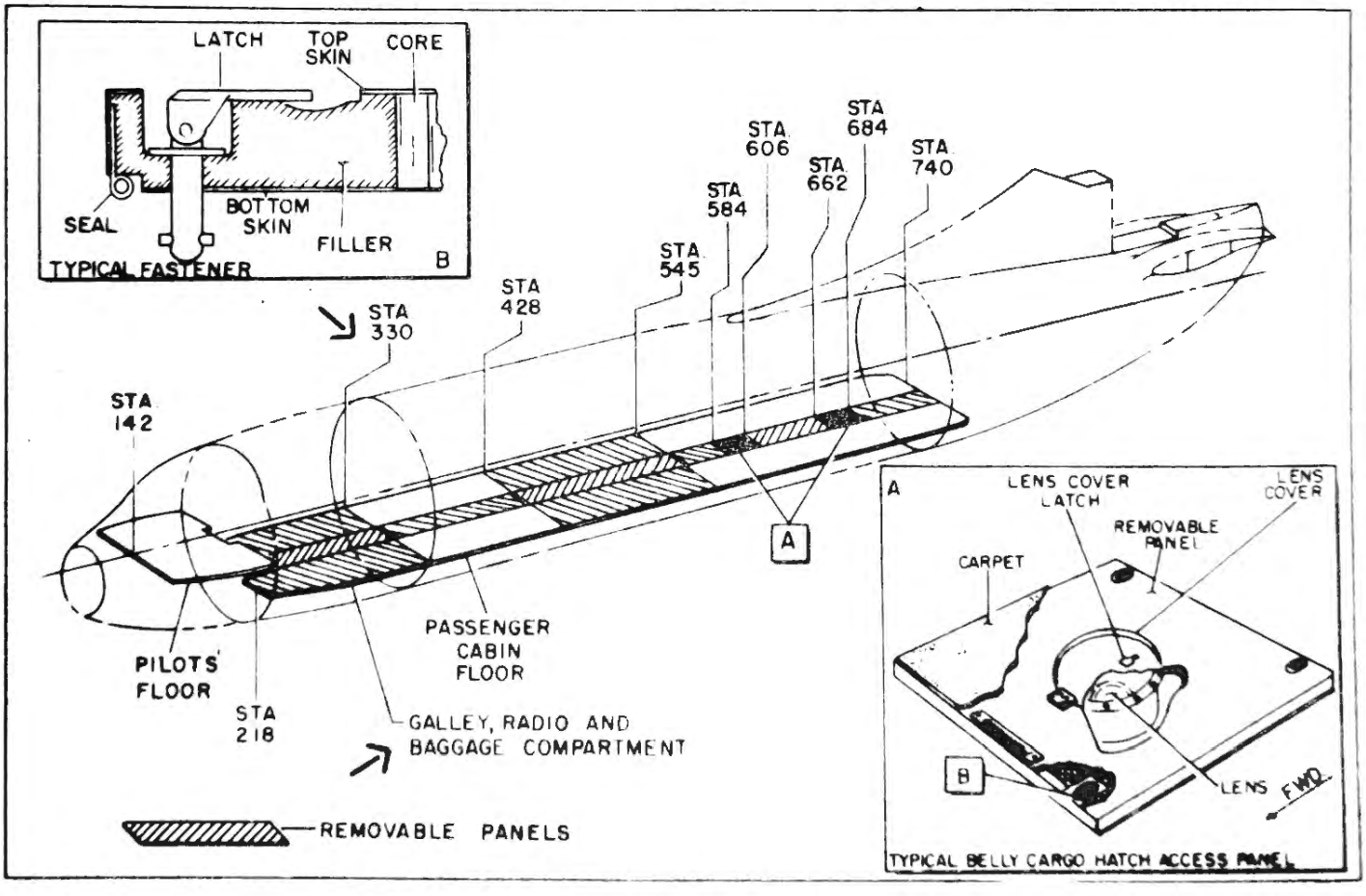


Figure 4. Fuselage Floor Panels.

Pilots' Compartment - General

The pilots' compartment contains seats and equipment for the pilots and observer. Windows and windshields are laminated plate glass and are arranged to provide maximum vision to crew members. Hydraulically operated windshield wipers are installed.

Entrance to the compartment is through the door at the aft end of the compartment. The observers seat is mounted on the forward side of this door and is folded up against the door when not in use.

For information on windshield anti-icing and window defogging, refer to Chapter 18. Refer to the 404 Structural Repair Manual for information on delamination limits of window glass. Refer to the applicable chapters for description of controls, instruments, equipment, heating and ventilating, and lighting of the pilots compartment.

Pilot's and Co-Pilot's Seat (See Figure 35)

The adjustable pilot's and co-pilot's seats are upholstered with sponge rubber cushions. Two channels attached to the bottom of each seat by bolts and anchor nuts, allow the seat to slide forward or aft on two tracks. Stops are attached at the ends of each track to prevent jamming of the seats. Each seat can be adjusted to a total of 10 inches in the fore and aft plane and a total of 5½ inches in the vertical place. The fore and aft position of the seat is controlled by a lever on the inboard side of each seat at the floor lever. Movement of this lever actuates the lockpin. When it is pulled aft the lockpin is disengaged and the seat can be moved to any desired position.

When the elevation control lever, located on the outboard side of each seat, is in the down position the lockpin is engaged to the vertical seat support. In pulling the lever up the lockpin is disengaged and the seat can be adjusted vertically. The pilot's left arm rest is not adjustable. The other arm rests can be adjusted approximately 3 inches by pulling the knob outboard on both sides of the vertical support. This action disengages the lockpin from the seat support frame. When the desired position is within adjustment release the knob so that the lockpin is engaged to the frame. The arm rests can be raised upward to facilitate entering or leaving. To remove the complete seat assembly from the airplane, remove the bolts which attach the seat to the channel.

Pilot's and Co-Pilot's Seat Belt

On the pilot's seat the buckle portion of the belt is attached to the right side of the seat and the strap portion is attached to the left side. On the co-pilot's seat the installation is the opposite.

Pilots' Windows

The windows of the pilots' compartment consist of two forward, double-panel windshields, two sliding, single-paned side windows, and two aft, fixed, single-paned windows. These are all right and left hand assemblies and are installed from the inside to reduce the possibility of a blow-out. In addition, there is a hinged clear vision window on the pilot's side, placed at an angle between the windshield and the sliding window. The right hand installation of this angle clear-vision window is fixed. All windshields and windows are sealed when closed to permit pressurization of the airplane. The pilots' windows permit maximum vision under all flying conditions.

Pilot's Windshield

The pilot's windshield is double-paned and so arranged that warm air is circulated between the panes for anti-icing. Refer to Chapter 17 and 18 for details. The outer panel is heat-treated plate glass. The inner panel is laminated semi-heat-treated plate glass and synthetic plastic with a metal insert around the outer edges. The outer panels are attached with screws and the inner panels are held in place by hinges and removable hinge pins at the top and bottom. This permits quick cleaning of the aft side of the outer panel and the forward side of the inner panel during unpressurized flight. The windshield installation is duplicated for the co-pilot.

Sliding Window

Each sliding window installation consists of a laminated plate glass panel assembled with a control arm and rollers which permit it to be opened for direct communication with ground personnel. A grooved track at the top and bottom of the window guides the roller travel. The window is sealed in the closed and locked position. The control arm effects simultaneous locking of the upper and lower locking components through the use of the torque tube.

Pilots' Fixed Windows (See Figure 38)

A fixed side window panel is located aft of each sliding window and consists of a laminated plate glass panel with metal strips on the outer edges. The window is sealed at installation with sealing tape.

Pilot's Clear Vision Window - See Figure 35

The laminated plate glass pilot's clear vision window is sealed hinged at the bottom and has a quick opening sliding latch at the top. Its purpose is to permit better visibility for the pilot by quick removal in the event the forward windshield becomes iced or clouded, or visibility is reduced from other causes. Rubber seals installed in the window frame provide for sealing the opening when the panel is installed and latched. The window is opened and removed by turning the latch handle and pulling inboard. When cabin pressure has dropped to approximately 1-3/4 psi the panel can be opened to depressurize the cabin.

The panel latch retaining spring is adjustable and should be adjusted as required to maintain adequate pressure on the latch shaft. Improper adjustment of this spring will permit the latch to vibrate and turn to the unlatched position during pressurized flight thus enabling the panel to fall open when the airplane is depressurized.

Pilots' Windshield Wiper System - General (See Figure 37)

The windshield wiper system provides for hydraulically operating the wipers. The 1500 psi closed center system supplies the pressure. The basic units of the system are two window wiper units with arm and wiper blade assemblies one micronic filter, one control unit, one speed control valve, and a shut off valve. Pressure is transmitted through the shut off valve to the speed control valve which starts and stops the wiper units and regulates their operating speeds by the amount of flow it admits to the control unit. Conventional aircraft hydraulic tubing is used which is attached to the structure by standard aircraft clamps and fittings.

Windshield Wiper System Operation (See Figure 39)

The windshield wipers are operated by opening the speed control valve located above the pilots' glare shield at the airplane center line. Hydraulic pressure from the closed center system is directed through the wiper shut-off valve located beneath the pilots' floor on the left hand side of the pilot's seat and through the micronic filter and speed control valve to the wiper control unit in the nose-wheel well and then to the wiper window unit. The wiper unit converts the hydraulic pressure into rotary motion to drive the wiper arms and blades. Each wiper unit incorporates a relief valve which allows a blade, limited by ice formation or any other cause to continue to operate within its limited sweep while the others operate normally. The motion of both blades will remain synchronized and operate in synchronization when one blade is kept completely free. The speed of the wipers is controlled by the wiper speed control valve which regulates the rate of flow of the hydraulic fluid from the source of pressure to the wiper control unit. The windshield wipers can be stopped by closing the speed control valve or the wiper shut-off valve.

Windshield Wiper Shut-off Valve - See Figure 37)

The hydraulic shut-off valve in the windshield wiper system is similar to the speed control valve. The difference is that this valve does not have an orifice in the inlet port. It is mounted beneath the pilot's floor on the left hand side of the pilot's seat at station 191. The control handwheel and shaft extends through the floor and is accessible to the pilot. The shut-off valve is in the main pressure line of the windshield wiper system. It is opened and closed by turning the control handwheel clockwise and counter clockwise respectively. Pressure can be maintained in the closed center hydraulic system by closing this valve in case leakage develops in any section or unit of the wiper system. It also isolates the wiper system from the closed center hydraulic system during servicing operations. This valve is kept open under normal conditions.

Windshield Wiper Control Valve (See Figure 37)

The control unit of the hydraulic windshield wiper system is the valve which distributes the pressure flow to the window units to perform these functions. It alternately directs the flow of hydraulic fluid first to one side, then to the other side of the window units, directs fluid discharged from the window units to the return line and hydraulically locks the window units in place when the system is not in operation. The control unit is located in the nose wheel well, on the forward side of the bulkhead at station 142. Conventional aircraft hydraulic tubing is connected to the unit.

Windshield Wiper Speed Control Valve (See Figure 37)

The windshield wiper speed control valve is used to start and stop the wipers and to vary their speed by controlling the rate of flow of the hydraulic fluid through the wiper system. This valve is mounted above the pilot's glare shield on the airplane center line and is available to both the pilot and co-pilot. A control handwheel permits the pilot to regulate the wiper speed as required. The body of the speed control valve houses a valve stem with a metering slot, a valve seat and an orifice. The handwheel threads the valve stem onto its seat, or away from it, depending upon the speed desired for wiper operation. The valve is closed by turning clockwise as far as possible. Opening the valve starts and increases the speed of the wiper arms. The speed

Windshield Wiper Speed Control Valve (See Figure 37) (Cont.)

control valve regulates the speed of both windshield wipers.

Windshield Wiper Window Unit (See Figure 37)

The windshield wiper hydraulic system contains two window units, each of which operates a wiper arm assembly. There is one each for the pilot's and co-pilot's windshields. The units convert hydraulic pressure into rotary motion to drive the wiper arm and blades. Each unit contains a relief valve, so that when the sweep of either blade is limited by any cause the obstructed blade continues to operate within its limited sweep while the second blade functions normally and both wipers remain synchronized in opposite sweeps. The window unit permits a wiper arm stroke of 93 degrees. The window units are mounted below the pilot's and co-pilot's windshields.

Windshield Wiper Arm and Blade Assembly

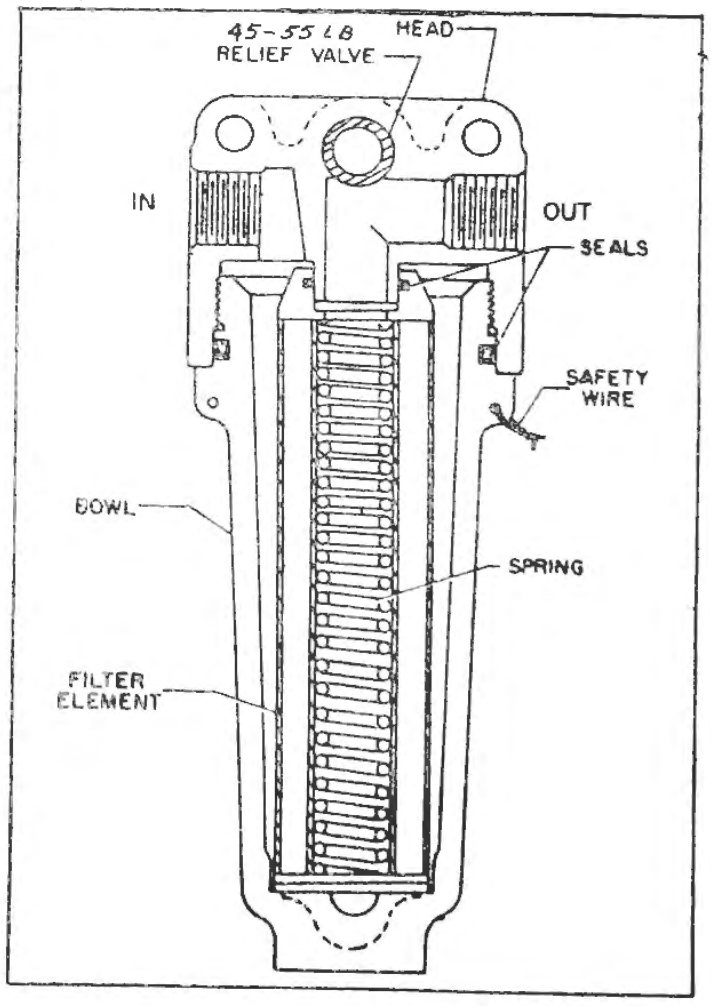
The windshield wiper arm assembly consists of the wiper blade, arm, arm clip, adjustment screw, lock nut, and spacer bushing. The rubber blade is 10" long and has a metal channel on the back, it is mounted on the arm assembly. It is attached at a 16 degree inboard angle. The serrated end of the arm fits into serrations on the shaft of the window unit and the lock nut on the arm clip permits adjustment of the desired angle between the arm and blade.

The wiper blade is replaceable and is attached to the arm assembly by the arm clip.

Windshield Wiper Filter

A 10 micron filter is installed in the windshield wiper hydraulic system up stream of the pilot's speed control valve to remove foreign particles from the fluid and prevent further restricting of the speed control valve orifice.

The filter element may be replaced by removing the filter bowl. When installing a new element, lubricate the "O" ring at the open end of the element with a small amount of hydraulic fluid then force element firmly on seat in head filter housing. Lubricate "O" ring on upper end of filter bowl then install on head and tighten.



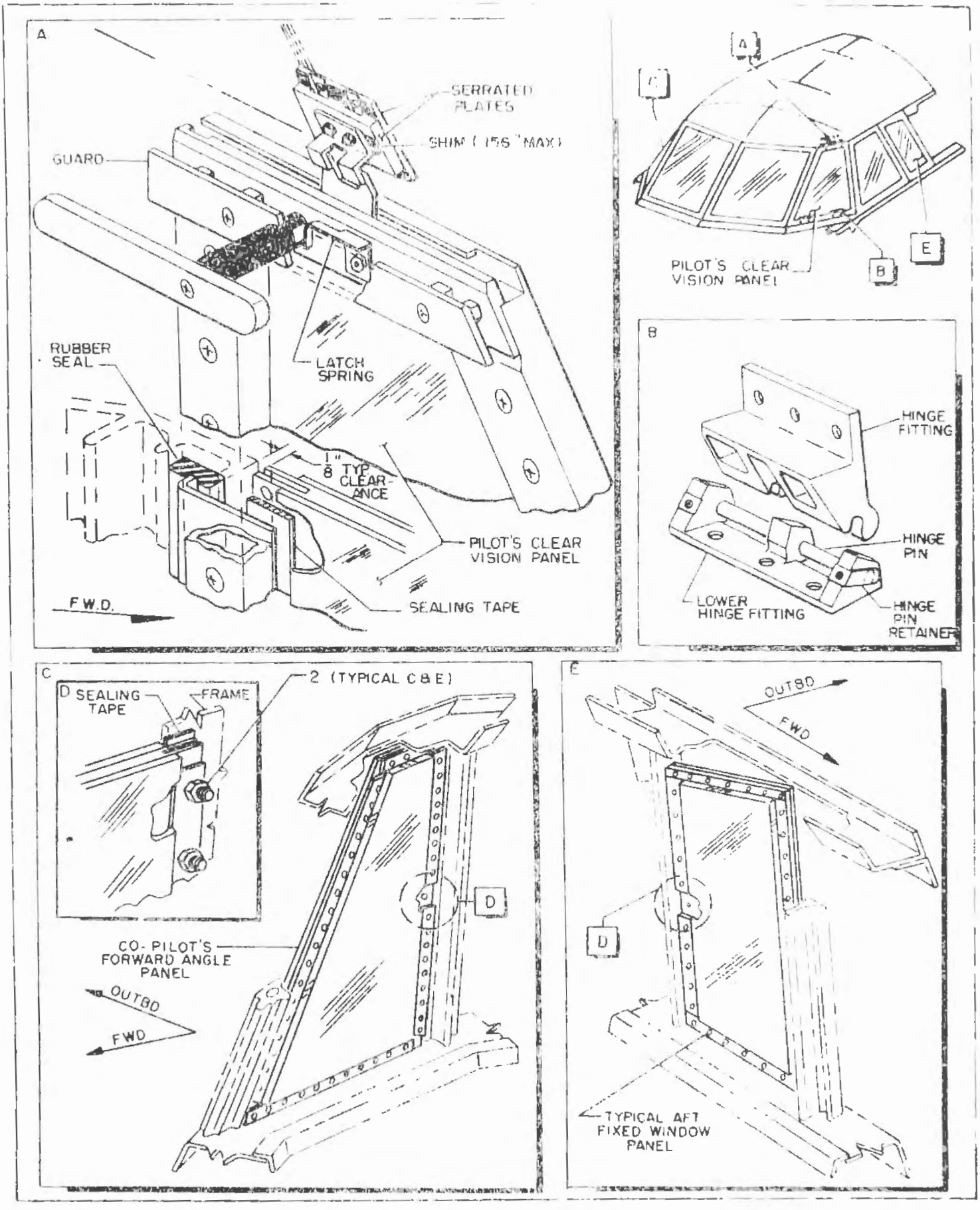


Figure 31. Pilots Compartment Windows

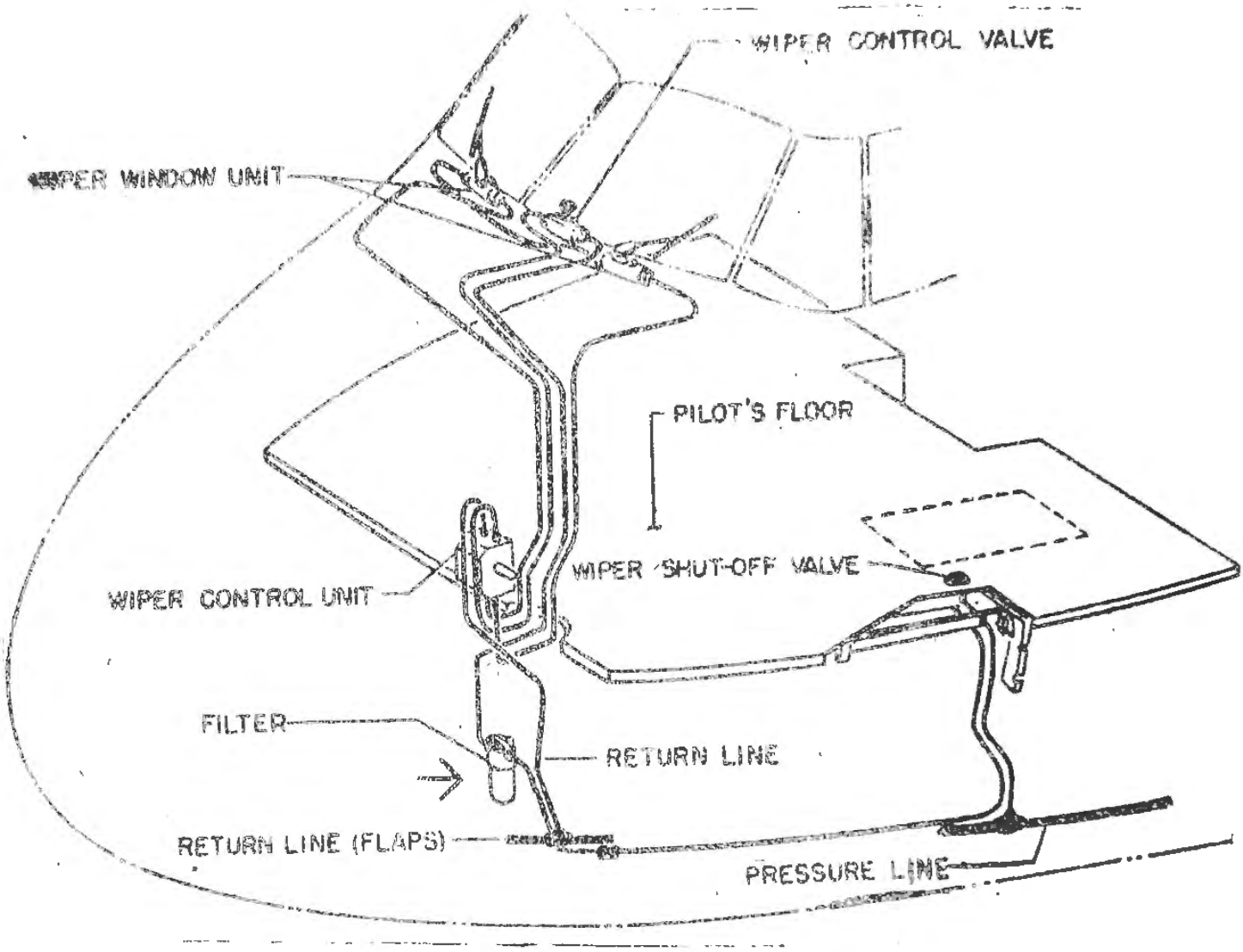


Figure 37. Windshield Wiper System Installation

Cabin Windows

The passenger compartment is provided with double-paned plastic (inner & outer) rectangular windows approximately 16 by 18 inches in size on each side adjacent to each passenger seat. The outer panel normally carries the loads imposed by pressurization of the fuselage and the aerodynamic pressure developed on the outside of the fuselage. The inner panel serves as a standby safety and is capable of taking over the loads carried by the outer panel if necessary. All of the panels are of a single layer (monolithic) type construction except the outer windows at window positions 1 thru 5, LH and RH, which are of the laminated type construction. The windows in this area are more susceptible to nicking from pebbles, etc., thrown off by the propellers. Using panels which have an abrasion sheet laminated on the outer surface provide a more dependable window installation. These windows are defogged by heated air passing between the inner and outer panes. Heated air for the passenger cabin windows is supplied by the cabin heating and ventilating system (refer to Chapter 17 for further description of the heating and ventilating system). The cabin windows at seat rows 4,5 and 8 on each side are designed as emergency escape hatches. Refer to section on Escape Hatches of this chapter for further information.

CAUTION

Cabin windows should be protected when spraying cabin with disinfectants. Disinfectants may cause windows to craze.

The inner window panels are secured in place with four Air-Loc fasteners and are easily removable for cleaning purposes. These inner window panels are interchangeable between windows and between airplanes, and also reversible from top to bottom.

Cabin Window Curtains.

Adjustable and removable cabin window curtains are located on each side of the cabin between the windows and may be moved so as to cover the window partially or completley. These curtains are secured by snaps to small tabs riding in tracks above and below the windows. These curtains may be removed for cleaning or replacement purposes simply by unsnaping them from the upper and lower tabs.

Passenger Reading Light Panels (See Figure 49)

A passenger reading light panel is provided for each row of seats on each side of the cabin, and is located in the lower surface of the overhead hat rack. These panels contain individual reading lights and fresh air outlets for the inboard and outboard seats and a single hostess call button. Oxygen outlets are provided on the panel for each passenger seat. Refer to sections on Reading Lights and Hostess Call Buttons of this Chapter for further information, and to Chapter 26 for wiring diagrams. Refer to Chapter 17 for further information on fresh air outlets. Refer to Chapter 20 for information on the oxygen system.

Drinking Fountain. (See Figure 7)

The drinking fountain is located on the right side of the aisle in the aft end of the cabin just forward of the lavatory door. This drinking fountain contains a removable six quart water container with a built-in faucet, a paper cup container and a waste paper cup container. The drinking water container is removed for servicing through the aft wall in the coat room. The waste paper cup container is serviced from the aisle and the paper cup dispenser through a door on the lavatory inboard wall.

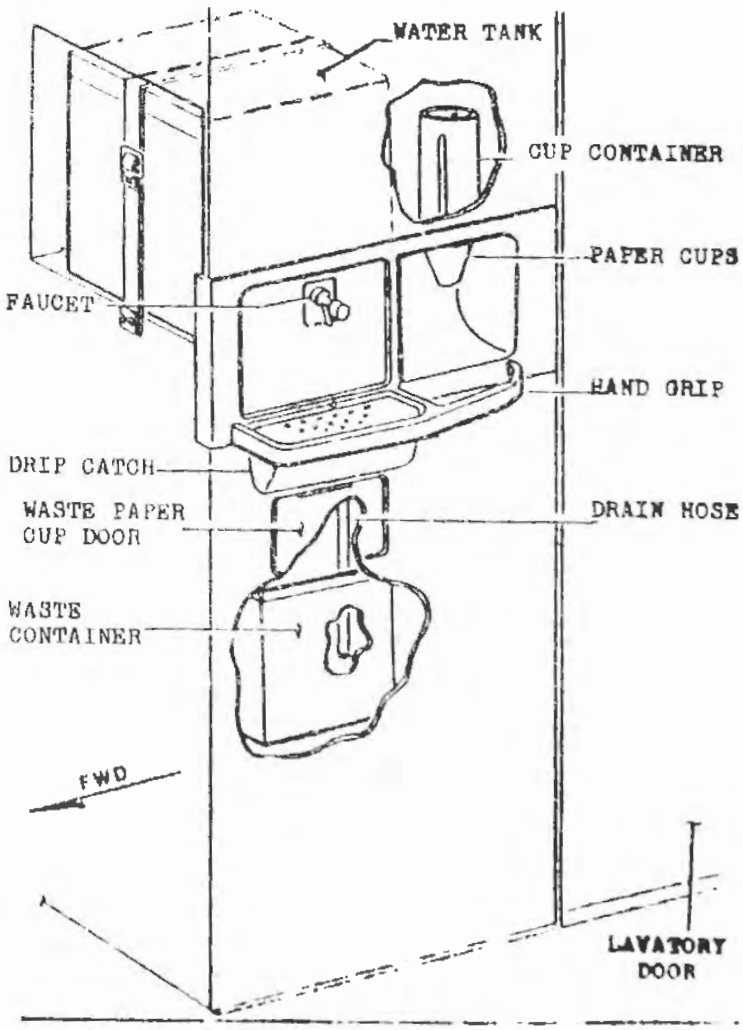


Figure 7. Drinking Fountain

Escape Hatches and Ropes (See Figure 45.)

Six emergency escape hatches are provided in the passenger compartment, three on each side at window locations 4, 5 and 8. An emergency escape rope is stowed above each escape hatch. (See figure 47). These escape hatches may be opened from either the interior or exterior of the fuselage by pulling on the handle on the top of the hatch on the interior, or by pushing on the release button on the exterior. The end of the escape ropes are stowed in the interior handle of each escape hatch and is automatically released with the opening of the hatch. All hatches open inward and are provided with seals to prevent cabin pressure leakage and to make them tight. Both the inner and outer window panels are identical are identical to the panels installed in the fuselage structure.

WARNING

When installing an emergency escape hatch (exit) the ditching rope placard (plastic tag attached to card) should be placed in the curve of the exit release handle before the actuating handle is moved to the closed position.

Floor Covering (See Figure 75, Series 4-2 Page 41)

The floor covering in the passenger compartment consists of a sponge-backed green vinyl floor covering under the seats and green carpeting in the aisle. The vinyl covering under the seats is installed in one section from the cabin forward bulkhead to the cabin aft bulkhead on both the L.H. and R.H. sides of the aircraft. Cut-outs are provided in the vinyl material at all seat tie-down stud locations. The vinyl floor covering is secured to the floor panels with double face rug tape. An extruded trim strip is installed over the vinyl along the intersection of the floor and the sidewall dado on both sides of theaircraft (Ref. View A-A, Fig. 75, Series 4-2 Page 41)

An extruded trim strip is installed over the vinyl between seat rows 2 and 3 to facilitate replacement of the forward section of vinyl if the need arises.

The aisle carpeting is installed in three sections. The two forward carpet sections are identical and are interchangeable between the M404 aircraft and LAC Model 049, 749 and 749A aircraft.

NOTE: No cut-outs are provided in the aisle carpets for any access doors. If the general area of the access door is known, it is a simple matter to peel back the carpet covering that access door. By eliminating cut-outs in the aisle carpets, the desired carpet interchangeability can be obtained.

The aisle carpets are installed under an extruded trim strip by means of double face rug tape.

The extruded trim strip runs the full length of the cabin on both sides of the aisle. These trim strips also serve to secure the vinyl floor covering along the aisle edge (Ref. View B-B, Fig. 75). The aisle carpet is held in place at the forward end of the cabin by means of a spring loaded threshhold plate. The carpet section is held in place at the rear of the cabin by means of a trim strip.

Access to Cargo Compartment Viewing Lens

Aisle carpets which cover the cargo compartment viewing lenses located in the removable floor panels at approximately BS 584 and 662 must be split to allow ready access to the lenses.

1. Locate cross-aisle center line of each lens.
2. Raise carpet at these points and insert a thin board or sheet of metal between the carpet and floor.
3. Using a straight edge and razor blade or sharp knife, split the carpet, 18 inches from one edge.
4. Remove backing plate, and fasten edges of carpet with double backed carpet tape.

PASSENGER RAMP SYSTEM - GENERAL (See Figure 11).

The passenger ramp system consists of the ramp, ramp controls, the hoisting and latching mechanisms, and the ramp hydraulic system. The ramp is hydraulically operated by power supplied from the Emergency Hydraulic Power System.

Operation Of Ramp System.

The aft passenger ramp is hydraulically operated and can be raised or lowered as desired from inside the airplane by means of an interior control handle.

To lower the ramp, press in and hold the electric switch which is located in the end of the control handle, this operates the emergency hydraulic pump that supplies pressure to the ramp control valve. With the pump operating, movement of the control handle from the "LOCK UP" position to the "DOWN" position disengages the up-lock mechanism and directs hydraulic pressure to the down port of the actuating cylinder. When the down-lock cylinder has locked the ramp in the down position, the control handle must be placed in the "STOW" position. This stows the handle out of the way and places the control valve in neutral.

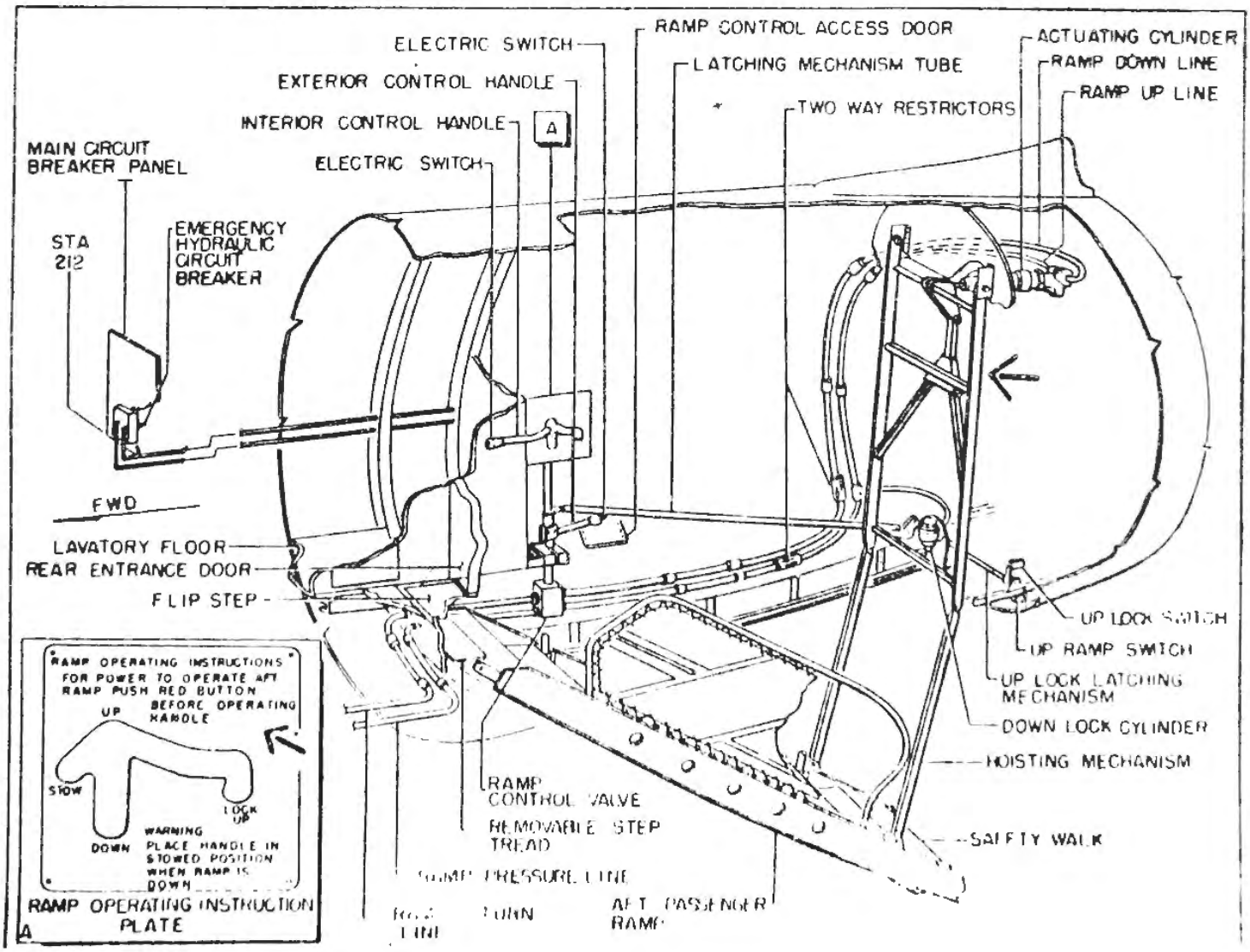
To raise the ramp start the emergency hydraulic pump, by holding in on the electric switch, and move the control handle from the "STOW" position to the "UP" position. This disengages the down-lock plunger and directs hydraulic pressure to the up port of the actuating cylinder. When the ramp is full up move the control handle to the "LOCK UP" position. With the handle in this position the up-lock is engaged and the control valve is in the neutral position (See figure 12).

CAUTION

The movement of the ramp controls from "LOCK UP" to "DOWN" should be made in one continuous action without hesitation or stoppage.

A similar switch for raising or lowering the ramp is no longer installed in the exterior ramp control handle.

Figure 11



Operation Of Ramp System (Cont.).

Two micro switches actuated by the up-lock mechanism and the entrance ramp respectively are located on the left hand side of the fuselage. Refer to Aft Ramp Lock Switch And Aft Ramp Position Switch in this chapter for details.

In the event of hydraulic failure the ramp can be lowered mechanically from inside or outside the airplane. This is accomplished by moving the control handle from the "LOCK UP" position to the "DOWN" position. This releases the up-lock and the ramp will drop slowly under its own weight. The ramp is protected against falling too fast, by the two-way restrictor in the operating line.

Ramp Hydraulic System.

Hydraulic pressure from the electrically driven hydraulic pump is used to lower and raise the aft passenger ramp, through a hoist assembly attached to the ramp.

The ramp hydraulic circuit consists of the following units: a control valve, one actuating cylinder, one down-lock cylinder and two two - way, restrictor valves. Actuation of the control valve to either "up" or "down" position results in flow of hydraulic fluid to the "up" or "down" port of the actuating cylinder. The cylinder converts this hydraulic pressure into mechanical energy, and the ramp is raised or lowered. The cylinder piston is retracted when the ramp is down, and extended when the ramp is up.

Two-way restrictor valves are installed in the operating lines of the control valve to regulate the speed of ramp operation. These restrictors limit the flow of hydraulic fluid into and out of the hoisting cylinder, thus reducing the speed of the piston travel, thus slowing down the speed of ramp operation.

A down-lock cylinder is inatalled in the "up" line of the ramp hoisting cylinder. The plunger of this cylinder serves as a lock-pin when the ramp is down to assure its remaining in this position. As pressure is directed into the up line for raising the ramp, it first actuates the plunger of the down-lock cylinder, unlocking the actuating mechanism, and then moves the actuating cylinder to the up position.

Passenger Ramp (See figure 11).

The aft passenger built-in entrance ramp, located on the lower center line of the airplane aft of the passenger compartment, is an all-metal stairway with nine steps, each of which is covered with a replaceable safety tread surface. Four of the step treads are removable allowing for inspection or repair of the enclosed portion of the ramp. A tubular hand rail is installed on each side of the ramp to assist passengers upon entering or leaving the airplane. An opening between the top of the handrails, and the sides of the ramp is covered with a fabric curtain. The outer surface of the ramp is contoured to conform with the under side of the fuselage, with the ramp in the closed position.

Ramp Controls (See figure 11).

The ramp controls conists of a latch control rod, a valve control rod, an interior control handle, an exterior control handle, a latch mechanism tube, two switch as and a hydraulic control valve.

The controls are located on the right hand side of the airplane aft of the lavatory rear bulkhead. The interior control handle is attached to the top of the latch control rod and is accessible from inside the airplane. The exterior control handle is attached to the lower end of the latch control rod and is accessable from outside the airplane through an access door in the side of the fuselage. Both these handles are linked to the valve control rod, which is located inside the latch control rod, and attached to the hydraulic control valve.

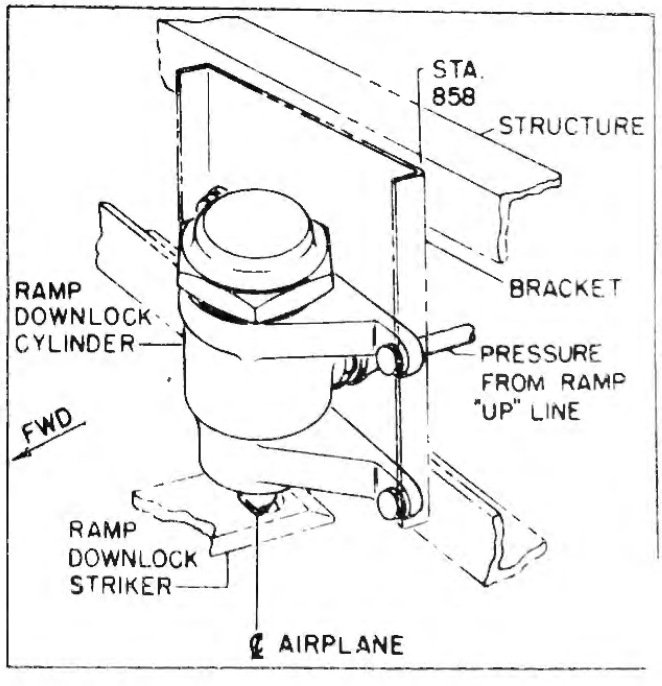


Figure 12. Ramp Downlock Cylinder

ENTRANCE DOORS AND HATCHES - GENERAL.

The fuselage doors and hatches consist of two exterior entrance doors, three interior doors and eight belly access doors. The exterior entrance doors are the forward and main entrance doors and they are used for the loading and unloading of passengers and cargo. The interior doors are the pilots' compartment door, the forward cabin door and the lavatory door. These doors are used for access to the respective compartments from the cabin interior. The belly access doors consist of eight doors located along the bottom of the airplane in the pressurized area and provide access to the units installed in the belly compartment and the belly cargo area.

EXTERIOR ENTRANCE DOORS.

Two exterior entrance doors are installed on the airplane. They are the forward entrance or cargo loading door and the passenger aft entrance door. Both doors are of all metal structure.

Main Entrance Door (See figure 61).

The main entrance door is located just forward of the entrance ramp and is used by the passengers and crew both in loading and unloading under normal operations. A spring-loaded flip step is mounted on the forward side of the door at the bottom. When the flip step catch is released the step swings upward. The flip step seals the area forward of the door for pressurized flight when in the closed and latched position. The main entrance door is hinged on the forward side and opens into the aft entrance compartment. Interior and exterior handles control the door latching mechanism. A window is mounted in the door near the top. The main entrance door is sealed all around to permit pressurization of the airplane. The flip step latch is controlled by a cable which is actuated by the movement of the main door handle. The main entrance door must be closed and latched before the flip step can be closed and latched.

Forward Entrance Door (See figure 55).

The forward entrance or cargo door is located on the left side of the airplane forward of the galley. The door has a clear opening width of 32 inches and a height of 60 inches. A small plastic window is provided at the upper section of the door. The door is held closed by 6 latching dogs, three on each side of the door. These latches are actuated by movement of either the interior or exterior door handle through a chain driven spider assembly. The door is hinged on the forward side and opens outward and forward. There is a hold-open latch mechanism that engages a latch pin located in the fuselage forward of the door hinge. A locking bar is provided which prevents the latching dogs from being operated when the door is in the open position. An emergency exit warning placard is located above the door. A handle to assist in closing the door is located at the top forward side of the door.

CAUTION

The warning on the emergency exit placard must be observed since the forward entrance door must remain closed while the left engine is running.

Operation of The Forward Entrance Door. (See figure 55).

The forward entrance door is operated by means of a spider assembly connected to the door handles which latches and unlatches the door in six places simultaneously. A locking bar located above the center latching dog at the aft edge of the door and in a door closed position is depressed against a catch on the aft door coaming. The latch dogs can be operated only when the locking bar is depressed. When unlatched the door swings outward and forward positioning the door in the open position clear to the fuselage. The outward and forward motion of the door receives it's original spring thrust from a spring loaded pin which applies pressure to the slotted hole hinge fitting at the time the door is unlatched. The door is equipped with a door hold-open mechanism which is mounted in the door between the center and lower latch dog. The mechanism consists of a spring loaded latch plate and control rod. A latch pin is mounted in the slotted fuselage area approximately 30 inches forward of the door hinge. The pressure of the forward door coaming against the control rod in the door closed position causes the mechanism to become spring loaded. When the door is unlatched and opened pressure is released from the control rod. This allows the latch plate to pivot out from the slot in the door ready for attachment to the latch pin in the fuselage. To close the door the control rod of the hold-open latch must be manually depressed to release the latch plate from the latch pin in the fuselage. The door can then be pulled aft by the handle on the top forward side of the door. A door handle on either side of the door permits opening and closing the door from either the inside or outside of the airplane. A safety switch installed in the door coaming forward of the door and at the upper dog latch attachment and operating in conjunction with the door handle; operates an indicator light marked "MAIN DOORS" on the co-pilot's console when the door is open or not securely latched.

Two open door warning lights are located on the co-pilot's console to indicate when any one or more doors are not closed and locked. One indicator light is marked "MAIN DOORS" and provides indication when any one or more of the following doors is not closed and locked: forward entrance door, aft entrance ramp, cabin pressure or aft entrance door. The other indicator light is marked "SERVICE DOORS", refer to Belly Access Doors in this chapter for details of this light.

INTERIOR DOORS.

Three interior doors are installed in the airplane. They are the pilots' compartment, the forward cabin entrance door and the lavatory door.

Pilots' Compartment Door (See figure 63).

The pilots' compartment door located at the entrance to the pilots' compartment is equipped with a lock which can be set to permit opening of the door from either the forward or aft side without a key or to require a key to open the door from the aft side. A ventilator is provided at the top of the door and can be opened or closed from the forward or aft side. Below the ventilator is a window which has a sliding panel that can be raised or lowered from the forward side of the door only. To keep the panel in the up or closed position attach button strap to the stud on the window frame. The flight observer's seat is located on the forward side of the door and folds up against the door in the stowed position. Refer to Flight Observer's Seat in this chapter for details. A CO_2 portable fire extinguisher is located below the flight observer's seat on a mounting bracket attached to the entrance door. An arrowed emergency exit placard is located beneath the window with the arrow pointing toward the forward entrance door (See figure 13).

Flight Observer's Seat (See figure 63).

The flight observer's seat located on the forward side of the pilots' compartment door is supported by four fittings in the pilots' compartment door coaming. The safety belt fittings are attached to studs which are located on plates at the upper seat support fittings. The restraint belt fittings are attached to pins provided for on both sides of the door coaming. The restraint belt is used to protect the flight observer from falling in case of any sudden opening of the pilots' compartment door. When not in use the seat can be stowed in an "up" position against the door by means of clamps and retaining belts. To stow the seat lift the front of the seat up until the clamp on each folding seat support attaches itself to the seat support. Then button the retaining straps to the studs on the bottom of the seat.

Lavatory Door.

A door of basic honeycomb structure is installed at the entrance to the lavatory compartment located across the aisle from the carry on baggage rack. The door is equipped with handle operated latching mechanism and a locking pin mechanism. When the door is closed the spring loaded latch in the door is engaged in a catch in the lavatory partition. The door can be locked or unlocked from the inside of the lavatory by turning of the lock lever located below the door handle. In the event of an emergency the door can be unlocked from the outside by turning the lock lever clockwise. An "OPEN" or "OCCUPIED" indicator is provided above the lock

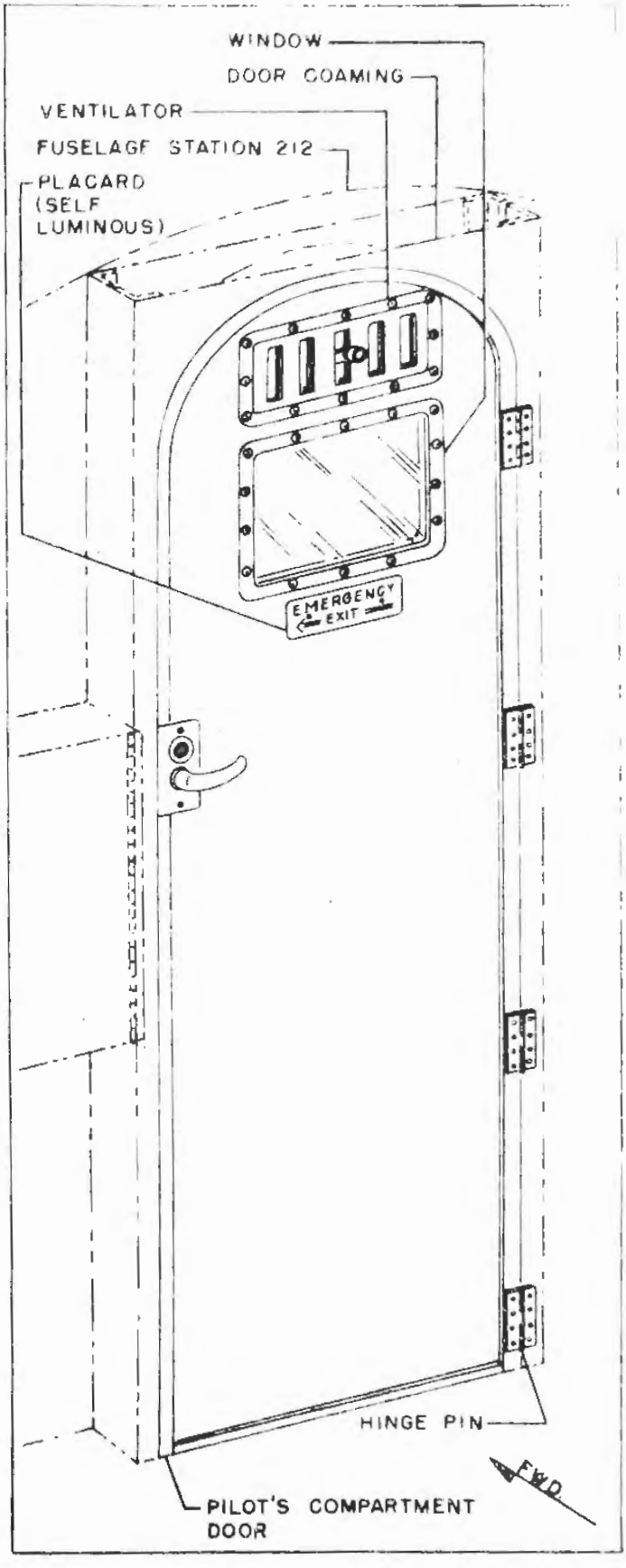


Figure 13. Aft Side Of Pilot's Compartment Door

Lavatory Door (Cont.).

and is controlled by the lockpin which also operates the electrical switch for the lavatory "IN USE" sign on the forward right side of the aft cabin bulkhead. Refer to Chapter 26 for wiring diagram of this circuit.

Belly Access Doors (See figure 57).

Eight access doors are installed along the bottom of the airplane in the pressurized area. The forward six doors are handle operated from the outside of the airplane only. The two aft or cargo access doors are handle operated, both from the inside and the outside of the airplane. Each of the doors is hinged at two places to brackets in the door coaming and swing down when open.

The closing and opening of each door is controlled by a handle operated latching mechanism and a locking rod. In closing and locking the door the locking rod is depressed against the door coaming allowing the operating handle to be turned. This action causes the latch dogs to be engaged in the latches in the door coaming and the locking rod engaged in a catch on the side of the coaming. The latching mechanism cannot operate unless the locking rod is depressed. An indicator light located on the co-pilot's console and marked "SERVICE DOORS" will glow when one or more of the belly service doors are not closed or locked. This light is actuated by a switch installed in the coaming of the respective door. Refer to Chapter 26 for wiring diagrams of this circuit. A replaceable synthetic rubber seal is provided around the door to prevent leaks when the airplane is pressurized. To remove the door from the airplane, position the door in the open position and remove the two bolts and nuts in the hinge bracket.

It is intended that the belly access doors be maintained in good repair. However, if a hinge on one of the pressurized belly doors should become broken and no spare is available, the door may be placed in position, the latch engaged and the flight dispatched. This is permitted because the latching and sealing qualities of the door do not depend upon the door hinges.

Two doors located in the aft lower right hand side of the fuselage provide access to the lavatory ground flushing and drainage fittings, and the ramp control handle respectively.

For location of access doors, covers, panels and latches see Chapter 1.

Forward Cabin Door (See figure 14).

The forward cabin door locatdd at station 330 bulkhead is of basic honeycomb structure. It is hinged at three places on the right hand side and opens forward into the galley compartment. It is equipped with a handle operated latching mechanism located at the left center of the door. A placard on the forward side of the door reads, "THIS DOOR TO BE OPENED DURING ALL TAKE-OFF AND LANDINGS." Provisions are incorporated on the radio rack to hold the door in an open position during take-offs and landings.

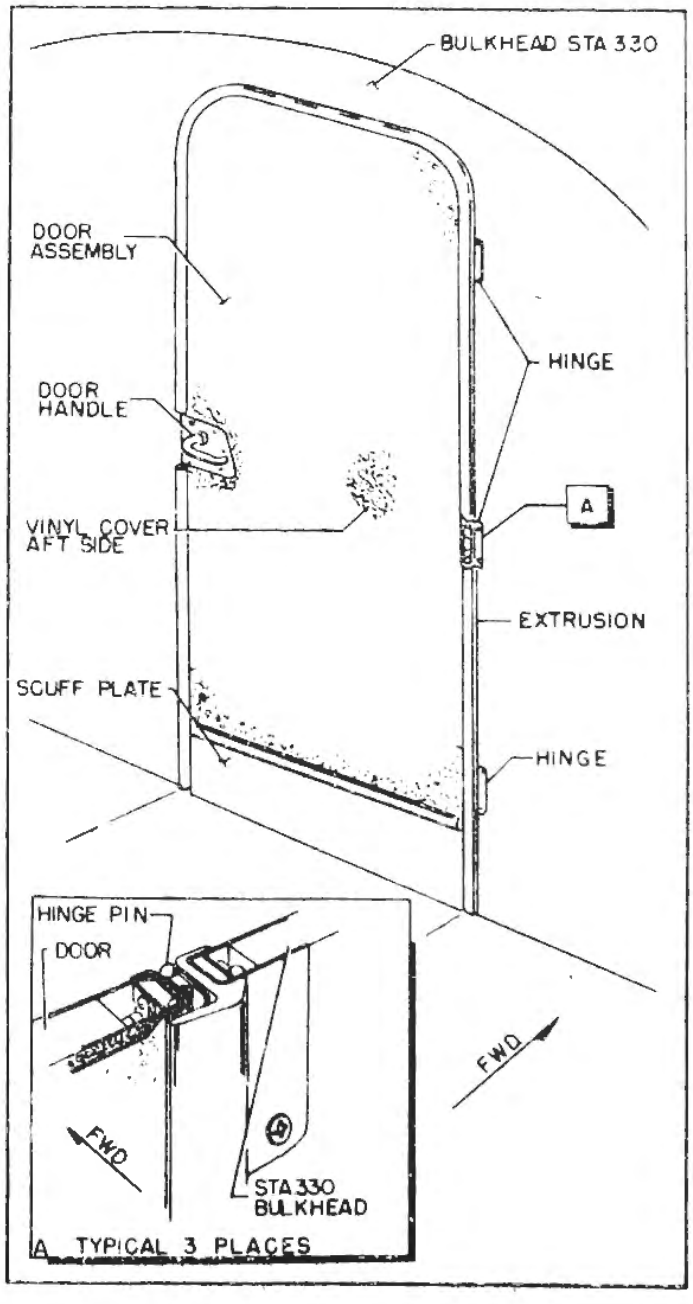


Figure 14. Forward Cabin Door.

BELLY COMPARTMENT LIGHTS AND INDICATION-GENERAL.

The belly compartment lights provides a means for illuminating the interior of the individual belly compartment, and the indication circuit to operate a red warning light, which will indicate to the pilot or co-pilot that one or more of the belly compartment service doors are not locked in the closed position.

The indicator light will operate when one or more of the following belly service doors are in the unlocked position;

Air Conditioning Access Hatch #80
Left Blower Access Hatch #82
Right Blower Access Hatch #82
Heater Access Hatch #83
Electrical Access Hatch #84
Rear Spar Access Hatch #86
Cargo Access Hatch #87
Cargo Access Hatch #88

Belly Compartment Lights And Indication Circuits.

The circuits consist of dome lights, indicator light, door actuated switches and a "CARGO COMPT. LIGHTS" switch.

Power for the circuit is supplied from the 28 volt d-c forward distribution bus through the "SERVICE LIGHTS" circuit breaker and the "DOOR INDICATOR" circuit breaker, located on the main circuit breaker panel (See figure 71).

Operation Of Belly Compartment Lights And Indicator Circuits.

With a 28 volt d-c power source energizing the forward distribution bus, and the "SERVICE LIGHTS" circuit breaker and the "DOOR INDICATOR" circuit breaker, located on the main circuit breaker panel in the "on" position, open one or more of the belly service doors and the red "SERVICE DOOR" indicator light, located on the co-pilot's console, will be illuminated. All belly compartment service doors must be in the locked closed position before the indicator light will be de-energized.

The individual compartment dome lights are operated by the "COMP'T. LT. SWITCH" located on the aft frame of the service door hatches, except for the left and right recirculation air blower access hatches where the "COMP'T. LT. SWITCH" is located on the forward frame.

The aft cargo compartment dome lights may be operated by their individual service door entrance switches or by the "CARGO COMPART. LIGHTS" switch, located on the hostess switch panel. The hostess "CARGO COMPART. LIGHTS" switch will operate both dome lights in the cargo compartment when the service doors are in the open or closed position.

Belly Compartment Dome Lights.

Each belly compartment dome light assembly contains a 21 candle power lamp covered with a metal grill. The lamp is accessible by removing three screws and loosening the remaining screw on the face of the metal grill. The light or lights are installed in each compartment to give illumination to their respective area.

Aft Cargo Compartment Dome Lights.

The two dome light assemblies located in the aft cargo compartment, are of the vapor proof type, containing a 32 candle power, single contact, bayonet base type lamp. The lamp is accessible by removing the screws holding the light assembly lens. The lights are used to illuminate the cargo compartment area when loading or unloading, or when inspection or emergency escape is made through the cabin flooring into the aft cargo compartment area.

"SERVICE DOORS" Indicator Light.

The "SERVICE DOORS" indicator light assembly, installed on the co-pilot's console panel, is of the push-to-test type containing a lamp, covered by a red jewel shade. The light assembly is accessible by removing the co-pilot's console panel, and the lamp of the light assembly is accessible by removing the red jewel shade. The light is used in the circuit to give indication to the pilot and co-pilot, that one or more of the belly compartment service doors are not locked in the closed position.

Hatch Switches.

There is a dual micro-switch assembly installed on the frame assembly at each of the belly compartment hatches. The switch assembly is installed so as to be actuated by the locking mechanism of the door. When the door is locked in the closed position, the locking mechanism will actuate the lever arm on the switch assembly, which in turn will actuate one of the micro switches and open the electrical circuit to the "SERVICE DOORS" indicator light. The other micro switch will be released, when the switch assembly lever is actuated, to its normally open position and open the circuit to the compartment dome light. When the door is unlocked the locking mechanism will release the lever, of the switch assembly, to its neutral position. This will allow the micro switch that was actuated to return to its normally closed contacts, and complete the circuit to the "SERVICE DOORS" indicator light. To illuminate the dome lights, the lever of the switch assembly will have to be manually pressed to the "ON" position.

Each switch is a single pole, double throw type, having a momentary closed contact and a normally closed contact.

"CARGO COMPART. LIGHTS." Switch (See figure 30).

The "CARGO COMPART. LIGHTS" switch is of the double pole, single throw type, toggle actuated switch. The switch is installed on the hostess switch panel and is accessible by opening the panel. The switch is used in the circuit to

CARGO COMPART. LIGHTS" Switch (Cont.).

illuminate the dome lights in the belly cargo compartment when the service doors are locked closed, and inspection or emergency escape is made throughthe cabin floor doors.

FORWARD ENTRANCE DOOR LIGHTS AND INDICATOR - GENERAL.

The forward entrance door lights and indicator warning light provides a means for illuminating the forward entrance door area and to indicate to the pilot or co-pilot that the forward entrance door is not in the locked closed position.

Forward Entrance Door Lights And Indicator Circuit.

The forward entrance door lights and indicator circuit consists of two white entrance light assemblies, a red indicator warning light assembly and a dual micro switch assembly.

Power is supplied to the circuit from the 28 volt d-c forward distribution bus through the "DOOR INDICATOR" circuit breaker and the "FWD. ENT. COMPT. LIGHTS" circuit breaker, located on the main circuit breaker panel. (See figure 71).

Operation Of Forward Entrance Door Lights Circuits.

With a 28 volt d-c power source energizing the forward distribution bus, turn on the "DOOR INDICATOR" and the "FWD. ENT. COMPT. LIGHTS" circuit breakers located on the main circuit breaker panel. When the forward entrance door is closed and locked, the two white lights installed on the inboard coaming above the entrance door and the red "MAIN DOORS" indicator light installed on the co-pilot's console panel, will be de-energized. When the forward entrance door is unlocked, the two white lights and the indicator light will be illuminated.

Forward Door Entrance Lights.

The two forward door entrance light assemblies are mounted on the inboard coaming above the forward entrance door. Each light assembly contains a lamp which is used to illuminate the forward entrance door area when energized. The lamps are accessible by removing the two thumb screws on the face of the light assembly.

"MAIN DOORS" Indicator Light.

The "MAIN DOORS" indicator light is of the push-to-test type, and having a red jewel shade over the internal lamp. The light is installed on the lower left hand corner of the co-pilot's console panel and is accessible by removing the panel from the console. The lamp is accessible by pulling the red jewel off the light assembly and turning the bayonet type lamp counter-clockwise. The light is used in the circuit to give indication to the pilot or co-pilot that the forward entrance door, aft entrance ramp, and the cabin pressure door are not locked in the closed position.

Forward Entrance Door Micro Switch.

The micro switch is of the double-pole, double-throw type, with the circuit being completed through the normally closed contacts. The micro switch is installed on the forward upper right hand side of the forward entrance door coaming and is accessible through the lighting hole beneath the sound proofing. The upper right hand latch on the forward entrance door is used to actuate the switch, when the door is in the locked closed position. The micro switch is used to operate two circuits. One circuit is from the "DOOR INDICATOR" circuit breaker to the "MAIN DOORS" indicator light, and the other circuit is from the "FWD. ENT. COMPT. LIGHTS" circuit breaker to the two forward entrance door light assemblies.

AFT RAMP ENTRANCE LIGHTS AND INDICATOR - GENERAL.

The aft ramp entrance lights and the indicator warning light provides a means for illuminating the aft entrance ramp area and to indicate to the pilot or co-pilot that the aft entrance ramp is not in the locked closed position.

Aft Ramp Entrance Lights And Indicator Circuits.

The aft ramp entrance lights and indicator circuits consists of three white entrance lights assemblies, a red indicator warning light assembly, ramp lock switch, ramp position switch and a "RAMP LIGHT" switch.

Power is supplied to the circuit from the 28 volt d-c forward distribution bus through the "DOOR INDICATOR" circuit breaker, located on the main circuit breaker panel. Power is also supplied to the circuit from the 28 volt d-c hostess bus through the "RAMP LIGHTS" circuit breaker, located on the hostess control panel.

Operation Of Aft Ramp Entrance Light Circuits.

With a 28 volt d-c power source energizing the forward distribution bus and the hostess bus, turn on the "DOOR INDICATOR" circuit breaker on the main circuit breaker panel and turn on the "RAMP LIGHTS" circuit breaker on the hostess switch panel. The "RAMP LIGHTS" switch located on the hostess switch panel, has an "OFF" and "ON" position and is used to operate the three white entrance lights when the entrance ramp is in the locked closed position. When the ramp is open, the three entrance lights will be illuminated and the red "MAIN DOORS" indicator light on the co-pilot's console will be illuminated. When the entrance ramp is closed the entrance lights and the indicator light will be de-energized.

Aft Ramp Entrance Lights.

There are three aft ramp entrance light assemblies used to illuminate the aft ramp entrance area. The light assemblies are installed aft and overhead in the entrance ramp well. Each light assembly contains a single contact bayonet type lamp, that is accessible by removing the two thumb screws on the face of the light assembly.

"MAIN DOORS" Indicator Light

The "MAIN DOORS" indicator light is of the push-to-test type, and having a red jewel shade over the internal lamp. The light is installed on the lower left hand corner of the co-pilot's console panel and is accessible by removing the panel from the console. The lamp is accessible by pulling the red jewel off the light assembly. The light is used in this circuit to give indication to the pilot or co-pilot that the aft entrance ramp, forward entrance door, and the cabin pressure door are not locked in the closed position.

Aft Ramp Lock Switch.

The aft ramp lock switch located on the left side of the entrance shelf, is mounted so as to be actuated by the up lock mechanism and will operate the entrance door lights and the red "MAIN DOORS" indicator light. The switch is of the micro double-pole double-throw type and is used to control the circuits from the "DOOR INDICATOR" circuit breaker and the "RAMP LIGHTS" circuit breaker.

Aft Ramp Position Switch.

The aft ramp position switch located at the aft left side in the ramp entrance door coaming, is mounted so as to be actuated by the entrance ramp and will operate the "MAIN DOORS" indicator light when not in the fully closed position. The switch is of the single-pole double-throw type, and is used to control the circuit from the "DOOR INDICATOR" circuit breaker.

"RAMP LIGHTS" Switch (See figure 30).

The "RAMP LIGHTS" switch located on the hostess switch panel, is of the single-pole, single-throw type. The switch is used in the circuit to operate the aft entrance lights when the entrance ramp is in the locked closed position.

CABIN PRESSURE DOOR INDICATOR LIGHT-GENERAL.

The cabin pressure door indicator light provides a means for illuminating the red "MAIN DOORS" warning light, to indicate to the pilot or co-pilot that the cabin pressure door is not in the locked closed position.

Cabin Pressure Door Indicator Light Circuit.

The cabin pressure door indicator light circuit consists of a cabin pressure door switch and a red warning indicator light assembly.

Power is supplied to the circuit from the 28 volt d-c forward distribution bus through the "DOOR INDICATOR" circuit breaker, located on the main circuit breaker panel. (See figure 71)

Operation Of Cabin Pressure Door Indicator Light Circuit.

With a 28 volt d-c power source energizing the forward distribution bus, turn on the "DOOR INDICATOR" circuit breaker. When the cabin pressure door is unlocked the red "MAIN DOORS" indicator light on the co-pilot's console will be illuminated. When the cabin pressure door is in the locked closed position, the warning indicator light will be de-energized.

Cabin Pressure Door Switch.

The cabin pressure door switch is located on the top step riser, forward of the passenger ramp and is actuated by the latching mechanism of the trip step. This trip step is hinged to the cabin pressure door. The switch is of the micro double-pole, double-throw type and is used to operate the circuit from the "DOOR INDICATOR" circuit breaker to the "MAIN DOORS" indicator light.

AFT ENTRANCE RAMP CONTROL CIRCUIT

The aft ramp control circuit provides a means for operating the emergency hydraulic pump by a switch installed on the inside ramp control handle. This permits emergency hydraulic pressure to operate the aft entrance ramp. A similar switch is no longer installed on the outside ramp control handle.

The circuit consists of a switch on the inside ramp control handle, remote control circuit breaker, and the emergency hydraulic pump. Power for the circuit is supplied from the 28 volt DC forward distribution bus through the "EMER. HYD. PUMP" circuit breaker.

Operation of Aft Entrance Ramp Control Circuit

With a 28 volt d-c power source energizing the forward distribution bus, place the "EMER. HYD. PUMP" circuit breaker, located on the main circuit breaker panel, to the "ON" position. Press the cap of the snap switch, installed in the end of the inside aft entrance ramp control handle, this will energize the remote control circuit breaker and cause the emergency hydraulic pump to operate. The pump will cause hydraulic pressure to build up and permit operation of the ramp when the control handle is moved to the open or closed position.

Aft Entrance Ramp Control Handle Switch

The switch installed in the inside ramp control handle is of the snap type, having a plunger cap to actuate the momentary closed contacts of the switch. The switch is used in the circuit to operate the emergency hydraulic pump. A similar switch is no longer installed on the outside ramp control handle.

NACELLE DOME LIGHTS CIRCUITS

The nacelle dome lights circuits provide a means for illuminating the areas in the nacelles. The circuit consists of two nacelle dome light and two "NACELLE LIGHT" switches located in the nacelles.

Power is supplied from the 28 volt d-c forward distribution bus through the "SERVICE LIGHTS" circuit breaker located on the main circuit breaker panel, to the "NACELLE LIGHT" switches.

Operation of Nacelle Dome Lights Circuit

With a 28 volt d-c power source supplying the generator bus and the "D-C LOAD" switches located on the overhead switch panel, in the "ON" position power is then available on the forward distribution bus. Power is then supplied through the "SERVICE LIGHTS" circuit breaker to each "NACELLE LIGHT" switch. Place either "NACELLE LIGHT" switch to the "ON" position and its respective nacelle dome light lamp will be illuminated.

Nacelle Dome Light

There is a nacelle dome light located in each nacelle forward of the front spar and is used to furnish light while working on the equipment in that area. Each nacelle dome light contains a single contact bayonet type lamp rated at fifty candle-power. The light assemblies are of the fume tight having a thick lens covering the internal lamp.

"NACELLE LIGHT" Switch

There are two "NACELLE LIGHT" switches, one located at the right aft section above the wheel well doors of each nacelle. The switches are of the single-pole single-throw type, toggle actuated to an "OFF" and "ON" position. The "NACELLE LIGHT" switches are supplied power from the 28 volt d-c forward distribution bus through the "SERVICE LIGHTS" circuit breaker and are used to open and close the feed circuit to its respective nacelle dome light lamp.

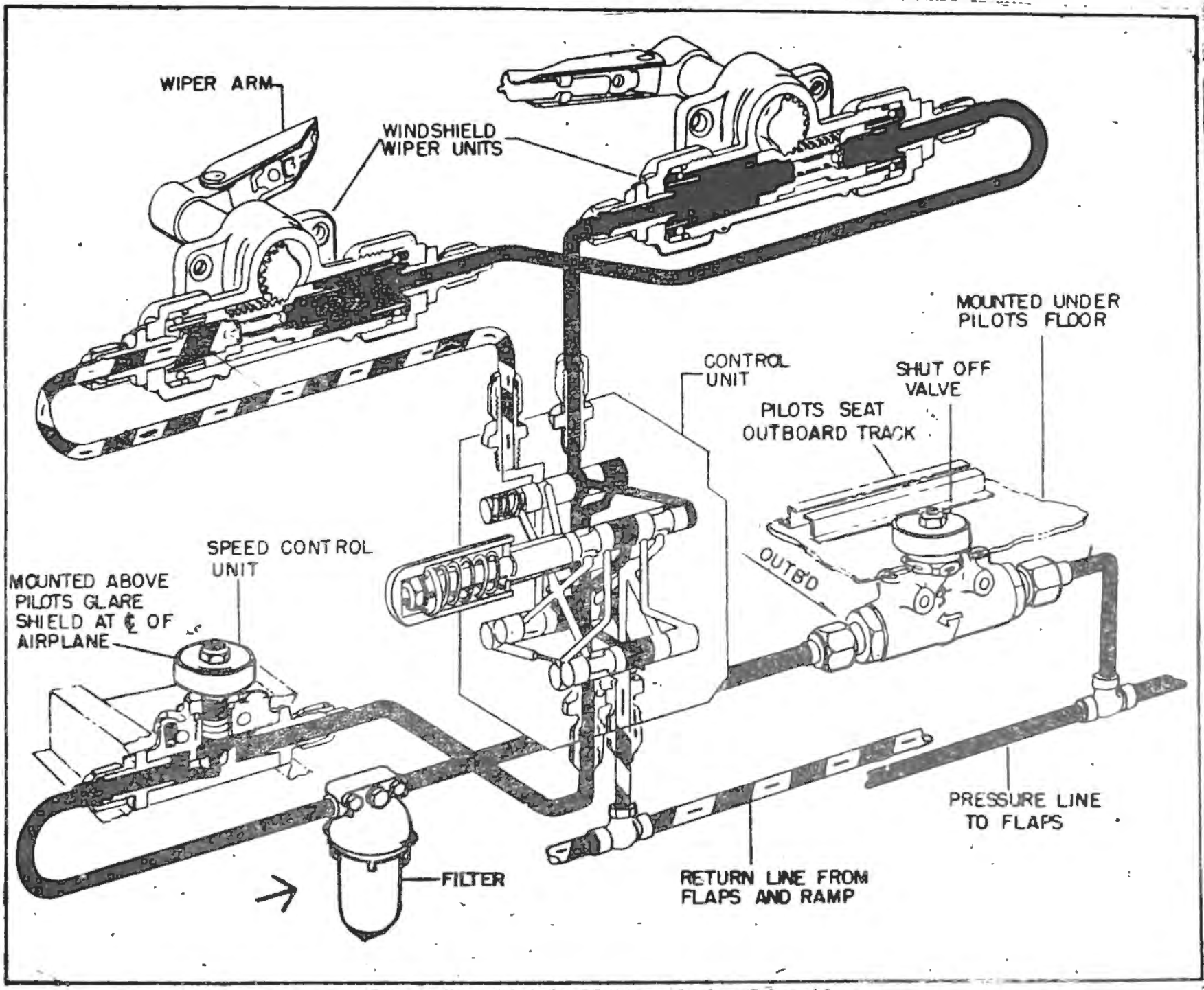


Figure 39. Windshield Wiper System Schematic -

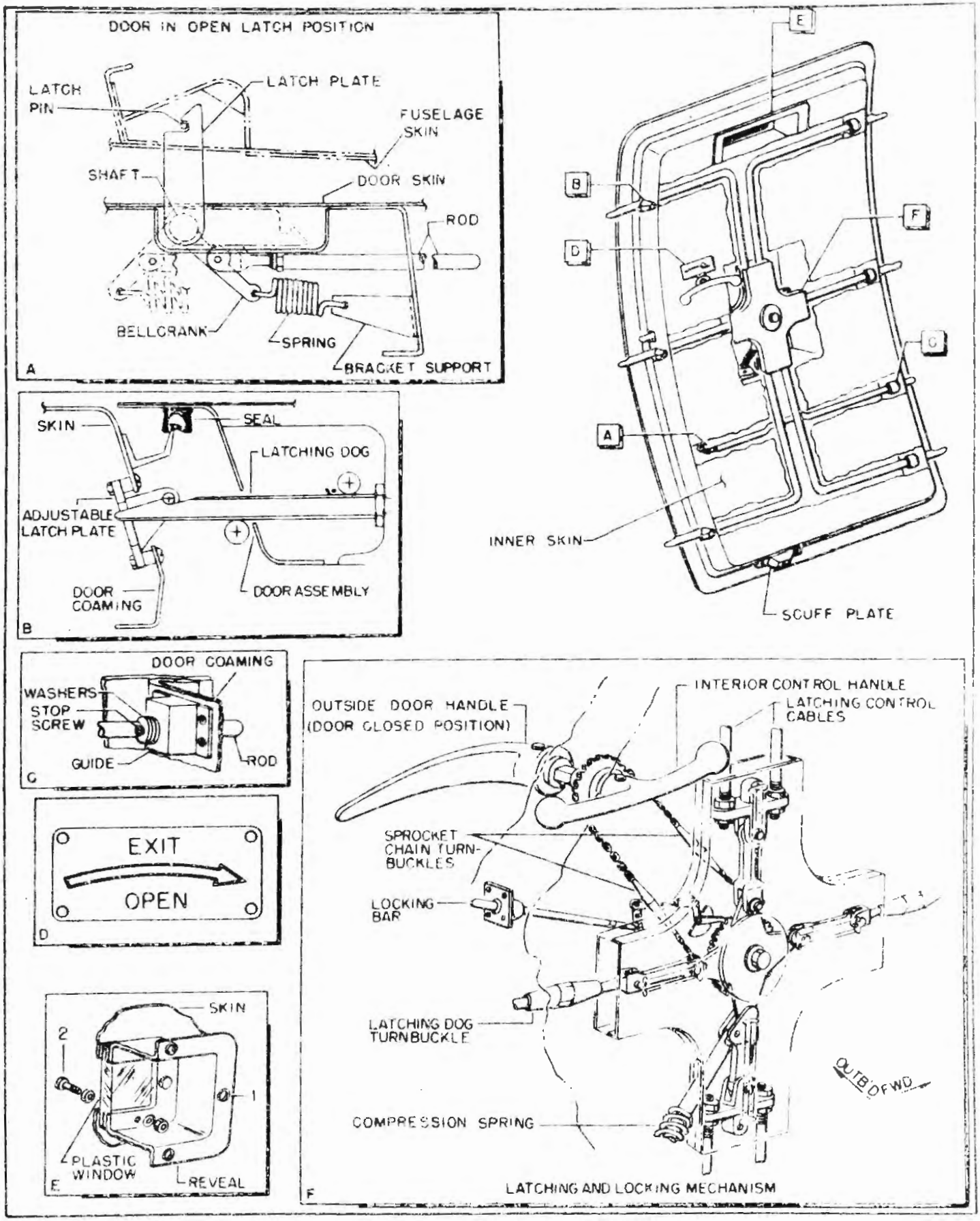


Figure 55. Forward Entrance Door

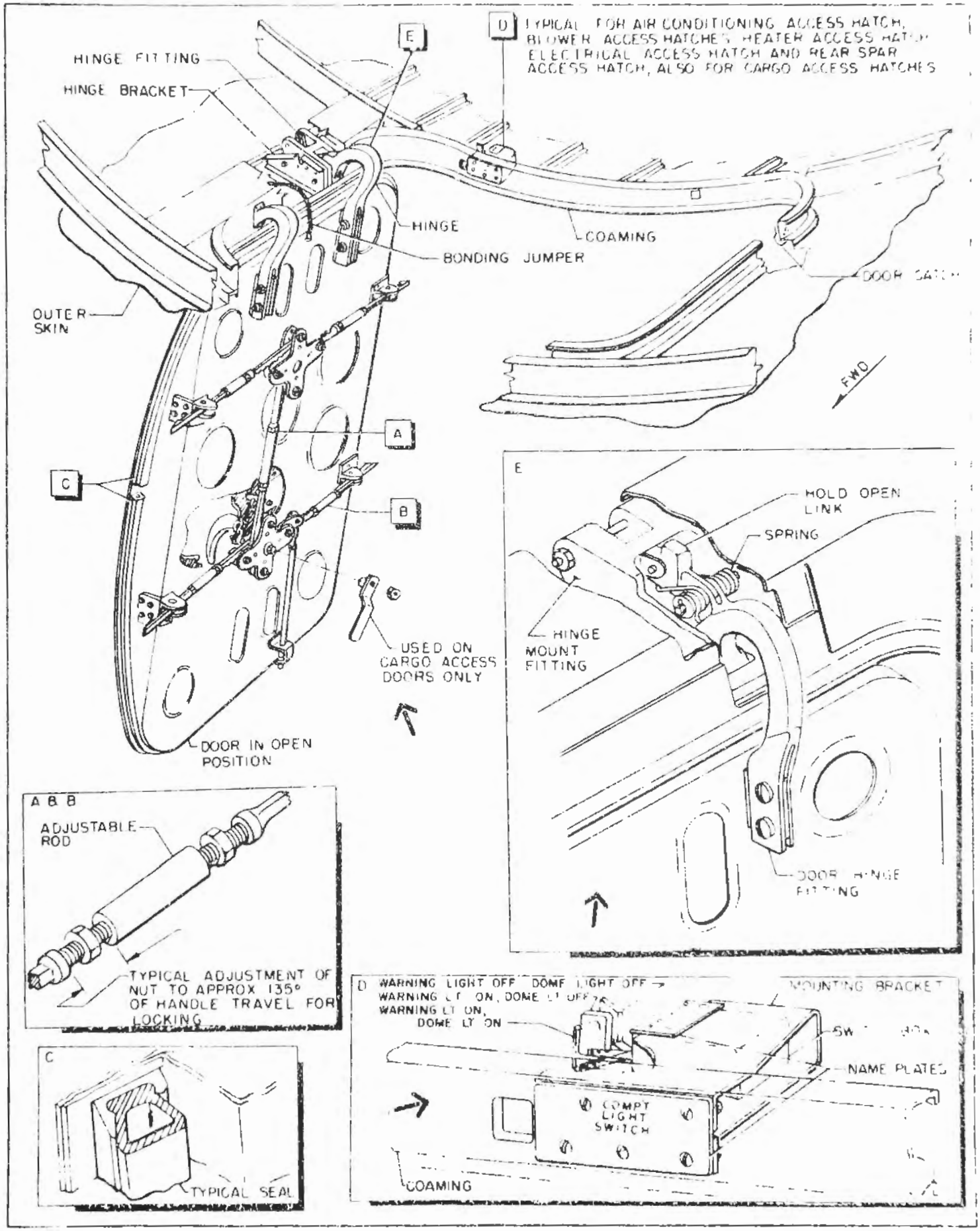


Figure 53. Fuselage Belly Access Door (Typical)

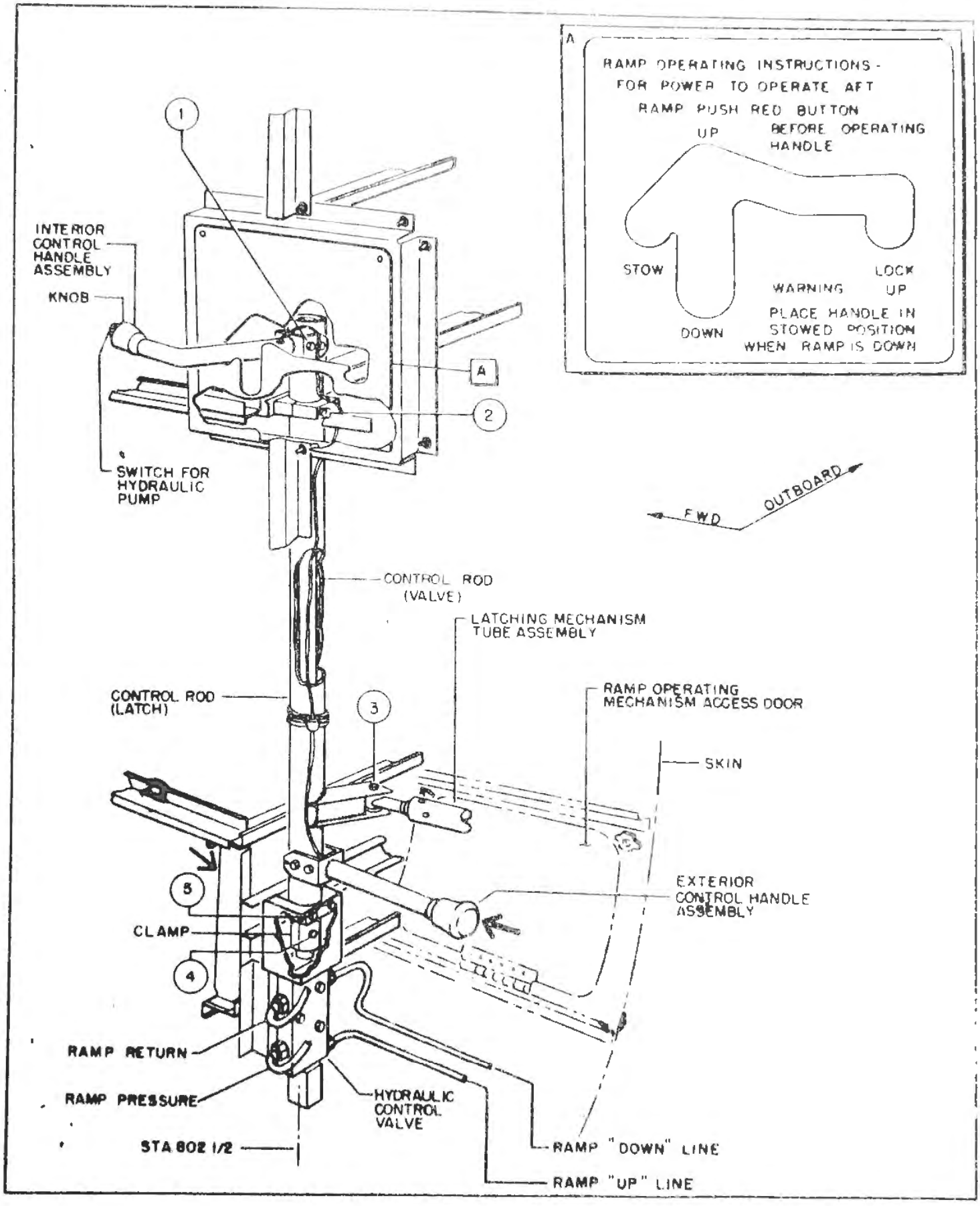


Figure 79. Ramp Controls Installed

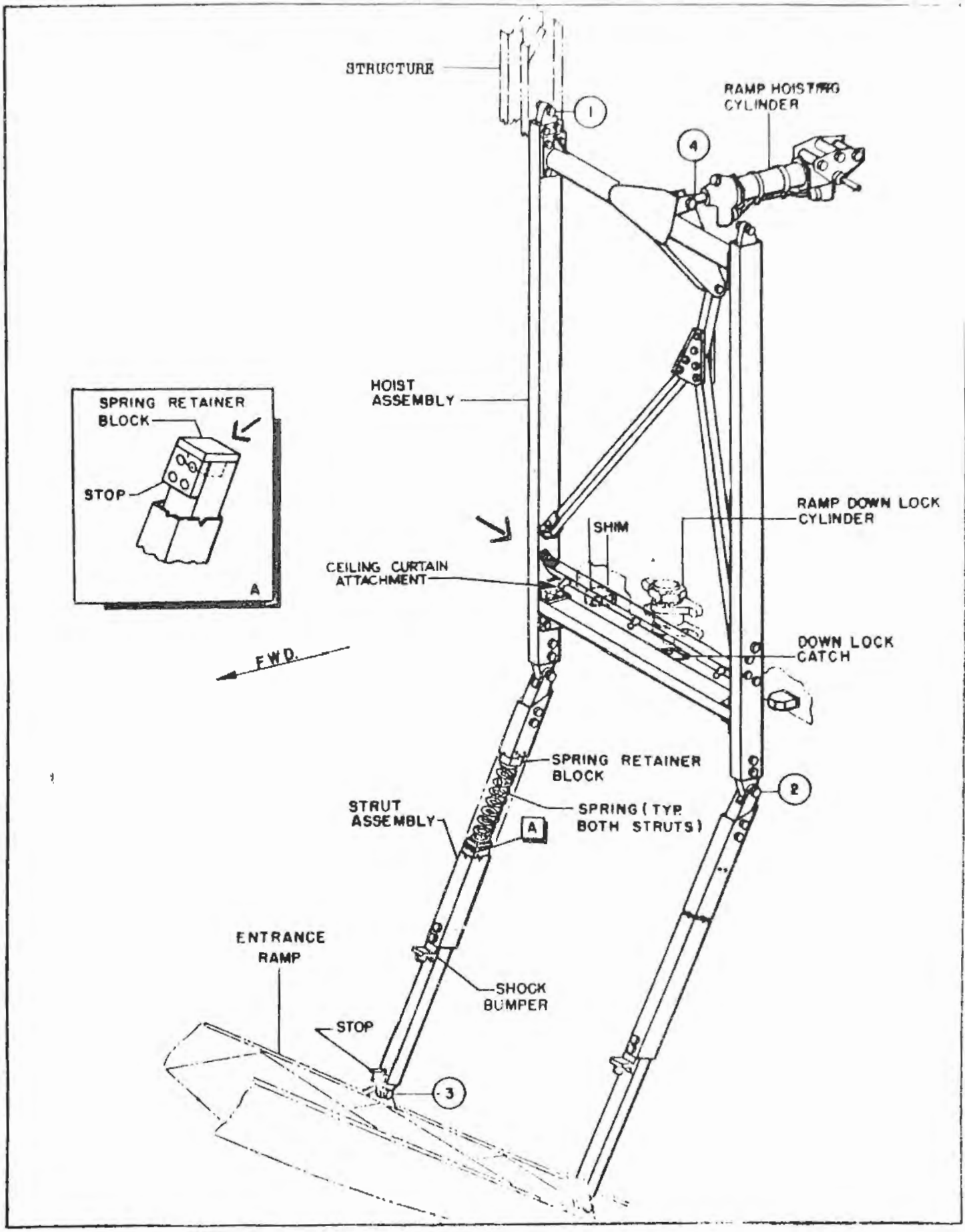


Figure 80. Ramp Hoisting Mechanism Installed

ILLUSTRATIONS OF PROPELLER OPERATION

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EMPENNAGE STRUCTURE - GENERAL.

The empennage group consists of a single fin and a variable incidence horizontal stabilizer. The rudder, elevator, trim tabs, and spring tabs are covered in Chapter 8.

HORIZONTAL STABILIZER.

The horizontal stabilizer is of the variable incidence type and is interconnected to the wing flap control system. It is designed in one piece extending through the fuselage. The horizontal stabilizer front spar, rear spar, and simplified rib assembly are covered with aluminum alloy sheet. The removable leading edge of the horizontal stabilizer is anti-iced and is in four sections on each side. It is constructed of formed aluminum alloy insulated to prevent dissipation of heat, except at the leading edge. The removable horizontal stabilizer tips contain an opening in the aft end for the warm air from the stabilizer anti-icing system to be exhausted. Two hinge points on the front spar, one on each side at horizontal stabilizer station 21, are attached to the fuselage at station 897. An aft hinge point on the rear spar is attached to a screw jack on the center line of the airplane at station 942. Access doors on the bottom surface of each side are provided for accessibility to the trim and spring tab linkage, and general inspection of the interior of the horizontal stabilizer. The horizontal stabilizer is interchangeable between airplanes. The stabilizer tips are interchangeable between stabilizers, and from left to right. The removable leading edges between stations 35 and 206 are replaceable.

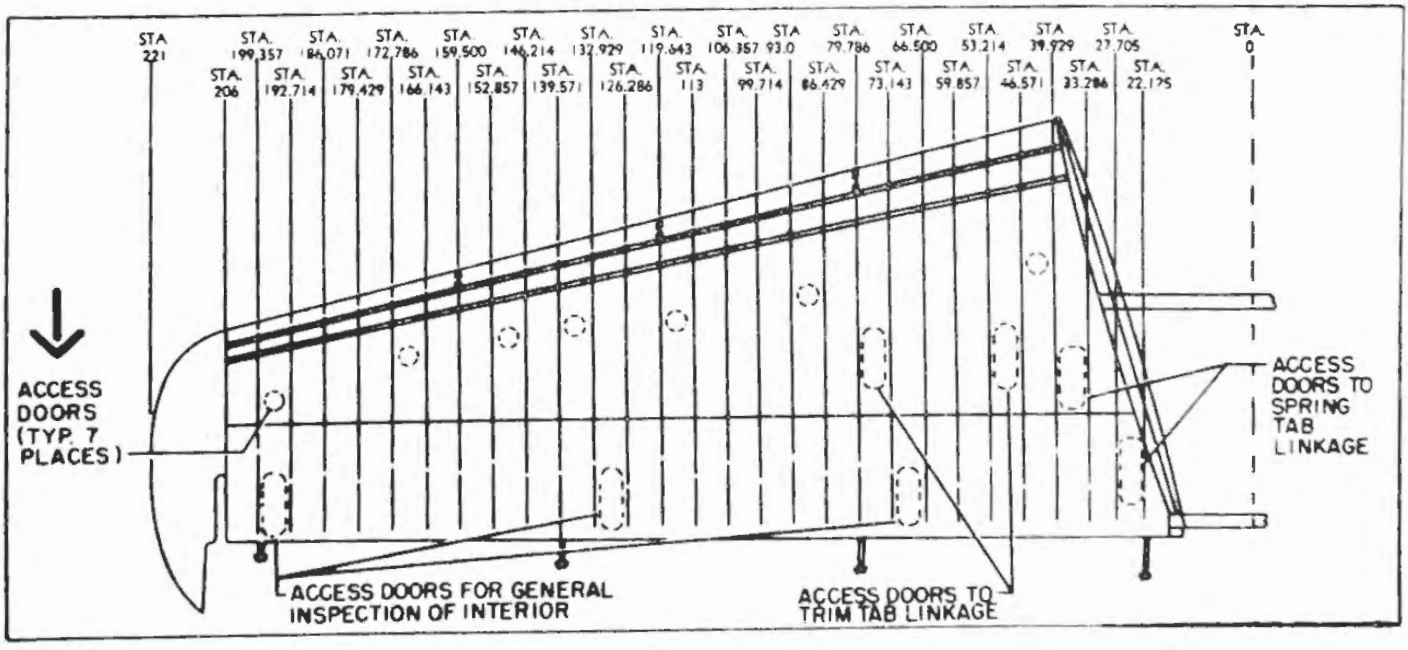


Figure 1. Horizontal Stabilizer Station Diagram

FIN.

The main body of the fin is constructed in one piece, and consists of a simplified rib and spar assembly covered with aluminum alloy sheet. The removable leading edge of the fin is anti-iced and is constructed of formed aluminum alloy insulated to prevent the dissipation of heat, except at the leading edge. A temperature bulb, which is located on the baffle of the removable leading edge, is used to register the temperature of the heated air in the empennage anti-icing system. This temperature bulb is accessible through a door on the upper left side of the fin just aft of the removable leading edge. The fin tip, which is also anti-iced at the leading edge, contains an opening in the aft end which allows the warm air from the fin anti-icing system to be exhausted overboard. The HF antenna attachment fitting is mounted to the removable leading edge just below the temperature bulb location at fin station 102.5. The three upper rudder hinge fittings are bolted to the fin rear spar while the bottom rudder hinge fitting is bolted to the fin rear spar and to the fuselage. Doors in the lower left side of the fin provide access to the rudder tab controls, the fin anti-icing duct, and the alignment pin. The main body of the fin is interchangeable between airplanes. The removable leading edge and the fin tip are interchangeable between fins.

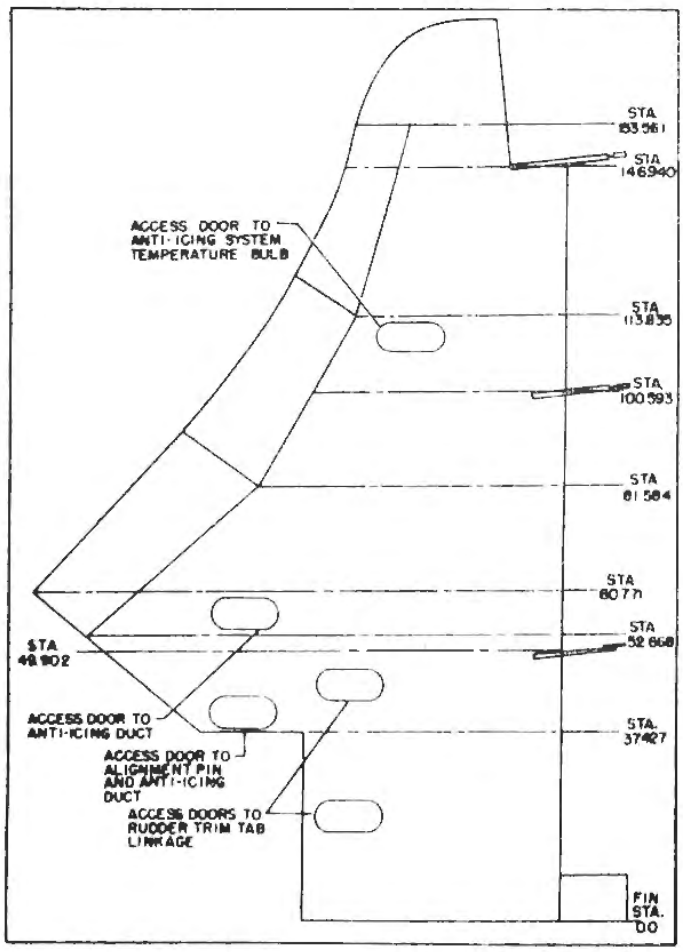
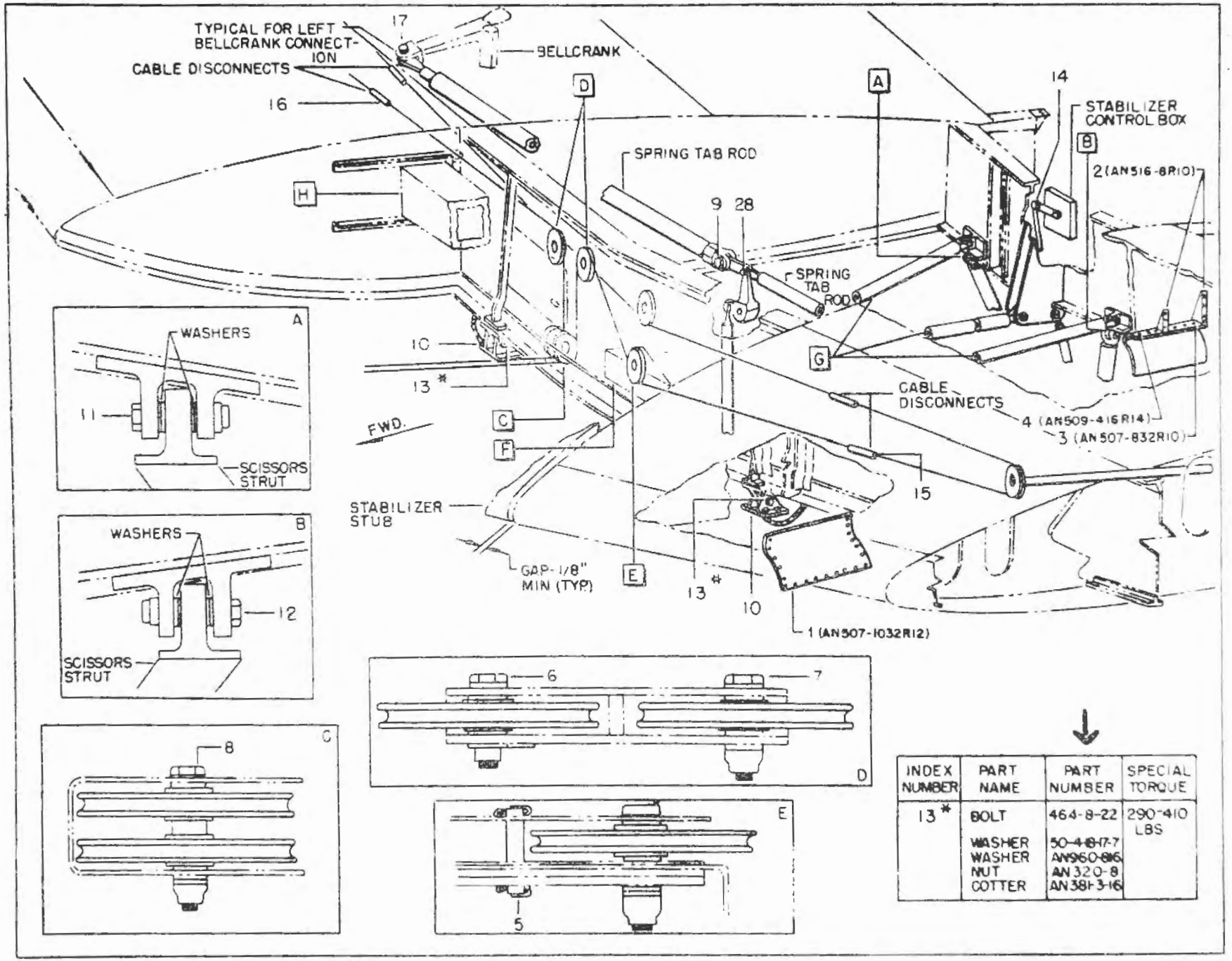
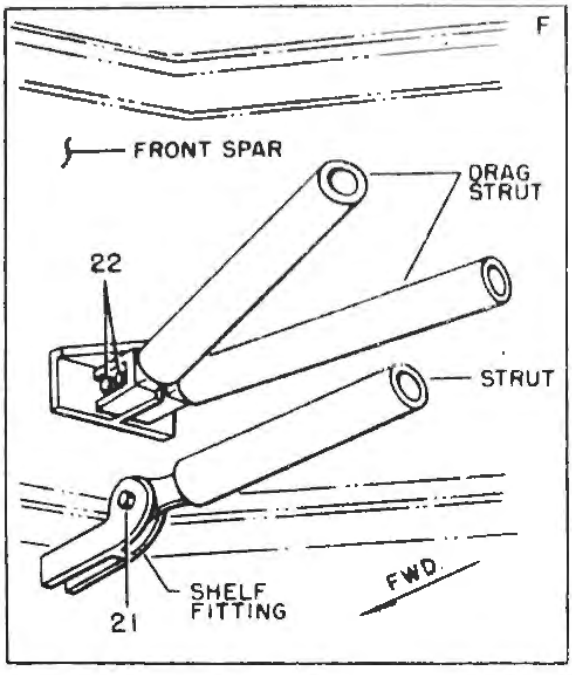


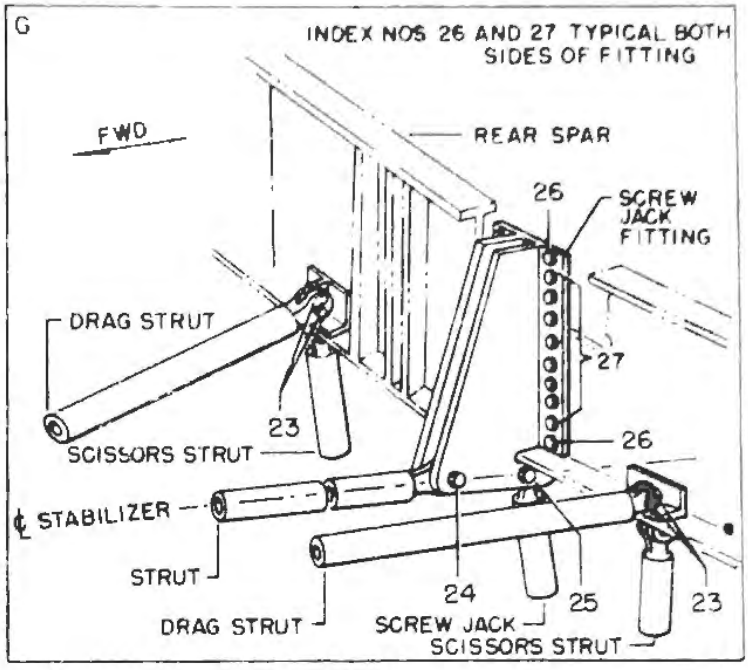
Figure 2. Fin Station Diagram



INDEX NUMBER	PART NAME	PART NUMBER	SPECIAL TORQUE
13 *	BOLT	464-8-22	290-410 LBS
	WASHER	50-448-17-7	
	WASHER	AN960-816	
	NUT	AN320-8	
	COTTER	AN381-3-16	

Figure 4. (Sheet 1 of 2 Sheets) Horizontal Stabilizer Installed





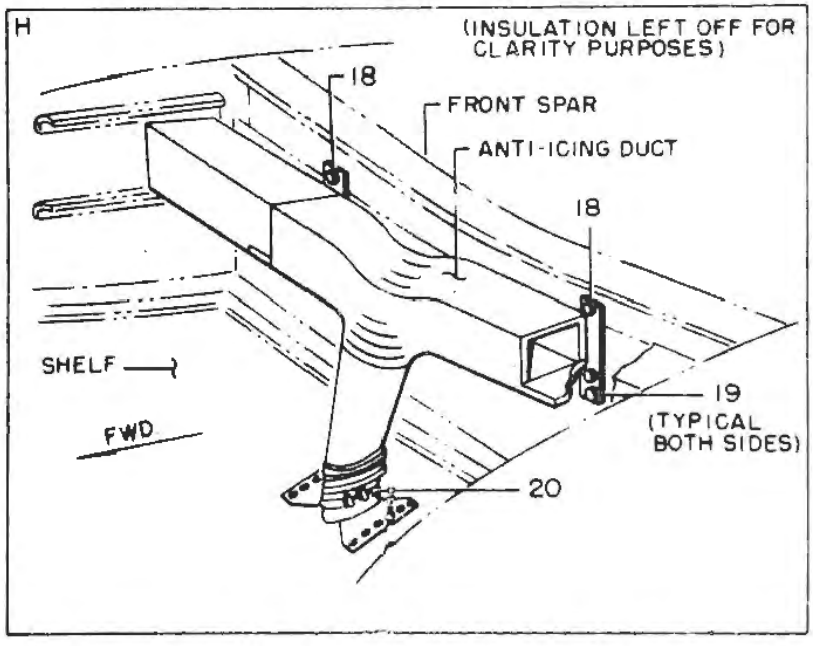


Figure 4. (Sheet 2 of 2 Sheets) Horizontal Stabilizer Installed

WING STRUCTURE-GENERAL

The wing group consists of three major sections; the center wing panel which is integral with the fuselage, and two removable outer wing panels. The wings are of the full cantilever, two spar, stressed skin type. Removable flaps, ailerons, flap slats, and shutter doors are mounted on the trailing edges of the wings. A removable wing tip is attached to the outer wing panels. Fuel cells and a landing light are located in each outer wing panel. The engine nacelles are mounted on the center wing.

OUTER WING (See figure 1).

There are two outer wing panels for each airplane, one left hand and one right hand. Each outer wing is constructed of conventional ribs and spars and is reinforced on the bottom side of the upper surface by corrugation plates and on the top side of the lower surface by (chordwise) stiffeners. Each wing is covered by stressed aluminum alloy skin. In the fuel tank area the wing upper surface consists of an inner smooth plate which, with the outer smootn skin, sandwiches the corrugations. The removable bottom fuel tank liners are made of honeycomb material as are the tank beam and wing rib at station 272.5. These units support the fuel cells and transfer stress loads to the wing structure.

The necessary attachment fittings and hinges are built into the wing to permit attachment and removal of the wing tip, aileron, outboard wing flap, slat, and the outer wing flap shutter doors.

Fuel tank access doors are installed in the lower surface of each outer wing, stations 230, 307, 366 and 421. There is an aileron quadrant access door in the lower surface of each wing at station 485. The wing structure, fuel tanks and other installations may be inspected and serviced through these access doors. Two tapped fittings are built into each outer wing on the top side, one in the front spar at station 312 and the other in the rear spar at station 319. The fittings are tapped to receive eye-bolts to which a sling can be attached for hoisting purposes. In order to replace an outer wing panel, it is necessary to use a special wing locating and reaming tool. The attaching bolts are installed through scarf splices and splice angles on the front and rear spar. Larger size bolts are used when a new wing is installed. The outer wing panels are replaceable but are not interchangeable among the airplanes.

A retractable landing light is installed in the lower surface of each outer wing.

Outer Wing Access Doors.

The outer wing access doors consist of the fluxgate compass access door; the aileron quadrant access door; six fuel tank access doors; and a fuel pump access door, all of which are located on the lower side of the wing. In addition, there is a fuel tank filler door located on the top side of the wing. The doors are attached to the wing by conventional piano type hinges and snap-locks or conventional stud-type spring fasteners. Refer to Chapter 1 for further information on access doors.

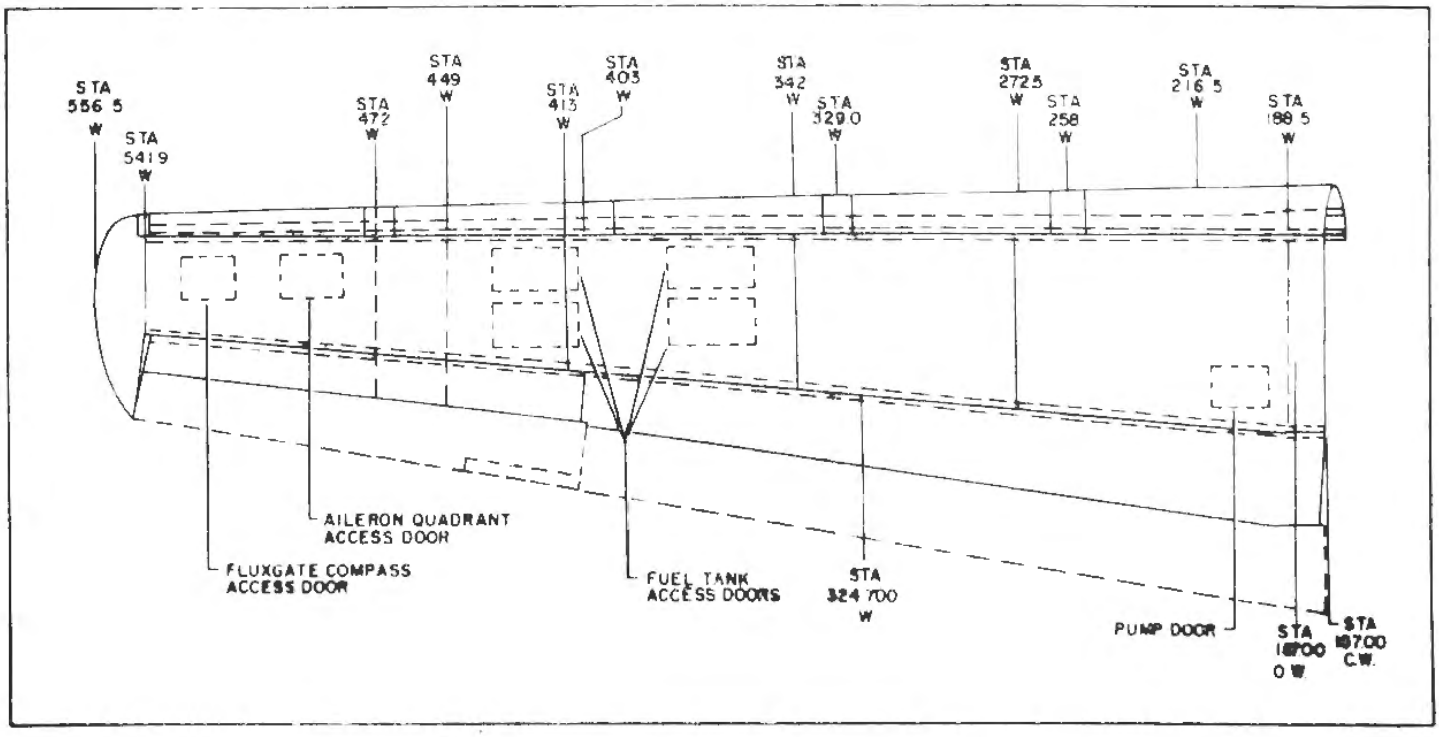


Figure 1. Outer Wing Station Diagram

WING TIP.

Each right and left hand wing tip consists of a conventional rib structure covered with aluminum alloy sheet. An opening in the trailing edge of the wing tip allows the warm air from the wing leading edge heat anti-icing duct to be exhausted. A navigation light is installed in the forward outboard part of the tip. Each wing tip is interchangeable among the airplanes for its respective wing and is attached to the outer wing panel by piano hinges and piano hinge wires. A cover is mounted over the gap on the leading edge. A screen is mounted over the exhaust opening in the trailing edge of the tip to keep out birds.

CENTER WING (See figure 2).

The center wing, which is an integral part of the fuselage, consists of two built up spars, ribs, stressed skin reinforced by corrugation on the upper surface and stressed skin on the lower surface reinforced by chordwise stiffeners.

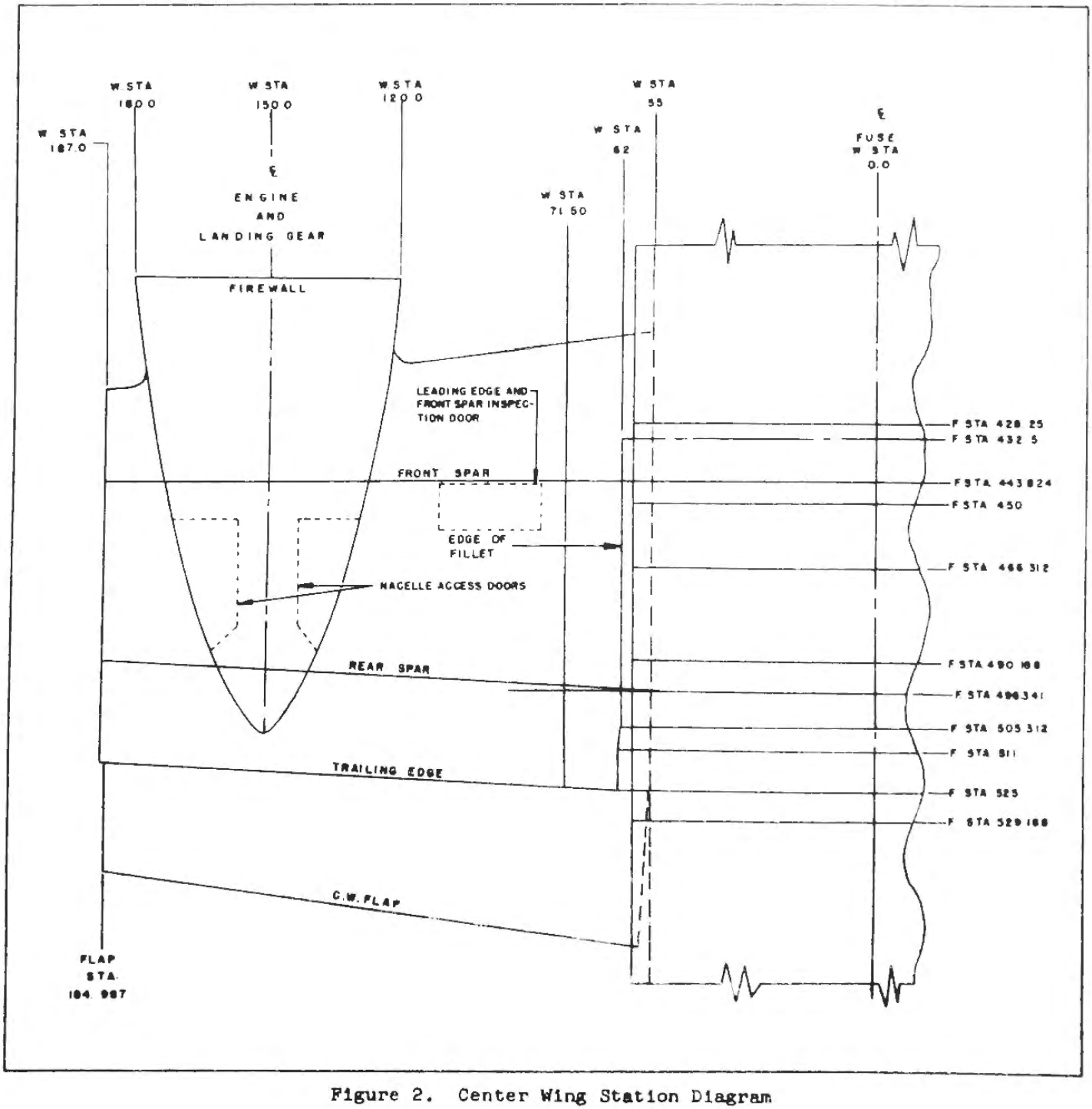


Figure 2. Center Wing Station Diagram

The corrugation reinforcement under the wing upper surface extends only between stations 55 and 187. The spars are of web construction, except through the fuselage where a truss type construction is used to permit circulation of air within the fuselage belly compartments and to permit inspection and service between spars.

The center wing is faired into the fuselage by detachable fillets installed on each side of the fuselage. Access doors are installed in the fillets for inspection purposes and for servicing the alcohol and ADI tanks.

The center wing trailing edges provide for installation of the center wing flaps, slats, and shutter doors. The center wing is not detachable from the fuselage. Access to fuel lines, aileron and aileron tab cables, and electrical cables is gained by dropping the flap shutter doors.

Two nacelles are located on the center wing, one on each side of the fuselage.

Access doors are provided on the lower side of the center wing to provide opening to the tubing, electrical and mechanical installations located in the center wing.

The center and outer wings are attached by bolted scarf splices at the lower chord of the front and rear spars in addition to wing chord splice angles which are mounted above and below the corrugation on both the center and outer wings. The wing chord splice angles are bolted together. Front and rear spar web splice angles on the center and outer wings are bolted together to complete the attachment of the outer wing to the center wing. Very close bolt fits are required.

Center Wing Access Doors.

There are six access doors located on each wing fillet and one under each center wing just aft of the leading edge. These access doors are attached by conventional piano hinges and snaplocks or conventional stud-type spring fasteners. The alcohol tank filler door is located on the right center wing to fuselage fillet and the ADI tank filler access door is located on the left fillet. Refer to Chapter 1 for further information on center wing access doors.

LEADING EDGES.

The baffled leading edges of the center and outer wing are heat anti-iced and are removable. An opening in each wing leading edge provides a flow of air to the anti-icing heaters. Each section of the leading edges is removable since it is attached by screws. All leading edge sections are replaceable. A fluted inner skin in each section permits heated air to travel under the outer skin back into the wing proper and heat the entire wing top skin except in the fuel tank area. Refer to Chapter 18 for anti-icing information.

NACELLES.

The engine nacelles are composed of a rear section which is an integral component of the center wing and an enclosure section located forward of the center wing front spar up to and including the firewall. This forward enclosure is a monocoque assembly that is fabricated separately and then bolted to the nacelle rear section and forward spar in such a manner that it can be removed. The firewall which is located just aft of the engine accessory compartment is made of corrosion resistant steel and incorporates an access door leading from the wheel well to the engine accessory compartment. The access door which is 26 x 28 inches, is attached by spring fasteners. Each of the nacelles contains the main wheel well, anti-icing heaters, various electrical junction boxes and the landing gear support and actuating mechanisms. A corrosion resistant steel plate is riveted adjacent to the nacelle aft of each exhaust tail pipe to protect and strengthen the skin.

Nacelle Access Doors.

The access doors located on each nacelle are the oil sequence valve access door; the engine mounting bolt access door; two lower nacelle access doors mounted adjacent to the strut door; and a firewall access door. All nacelle doors except lower nacelle access door are attached by conventional piano hinges and spring type fasteners. The firewall access doors are attached with spring fasteners only.

Each lower nacelle access door which provides access to the anti-icing heaters is of waffle type construction and is attached to the nacelle by conventional type winged stud fasteners and is supported at the forward and aft ends by adjustable support rods. Locating pins mounted on the nacelle prevent any movement of the door. Each door is interchangeable with the corresponding door on the opposite nacelle and with an identical door on other airplanes. Refer to Chapter 1 for further information on nacelle access doors.

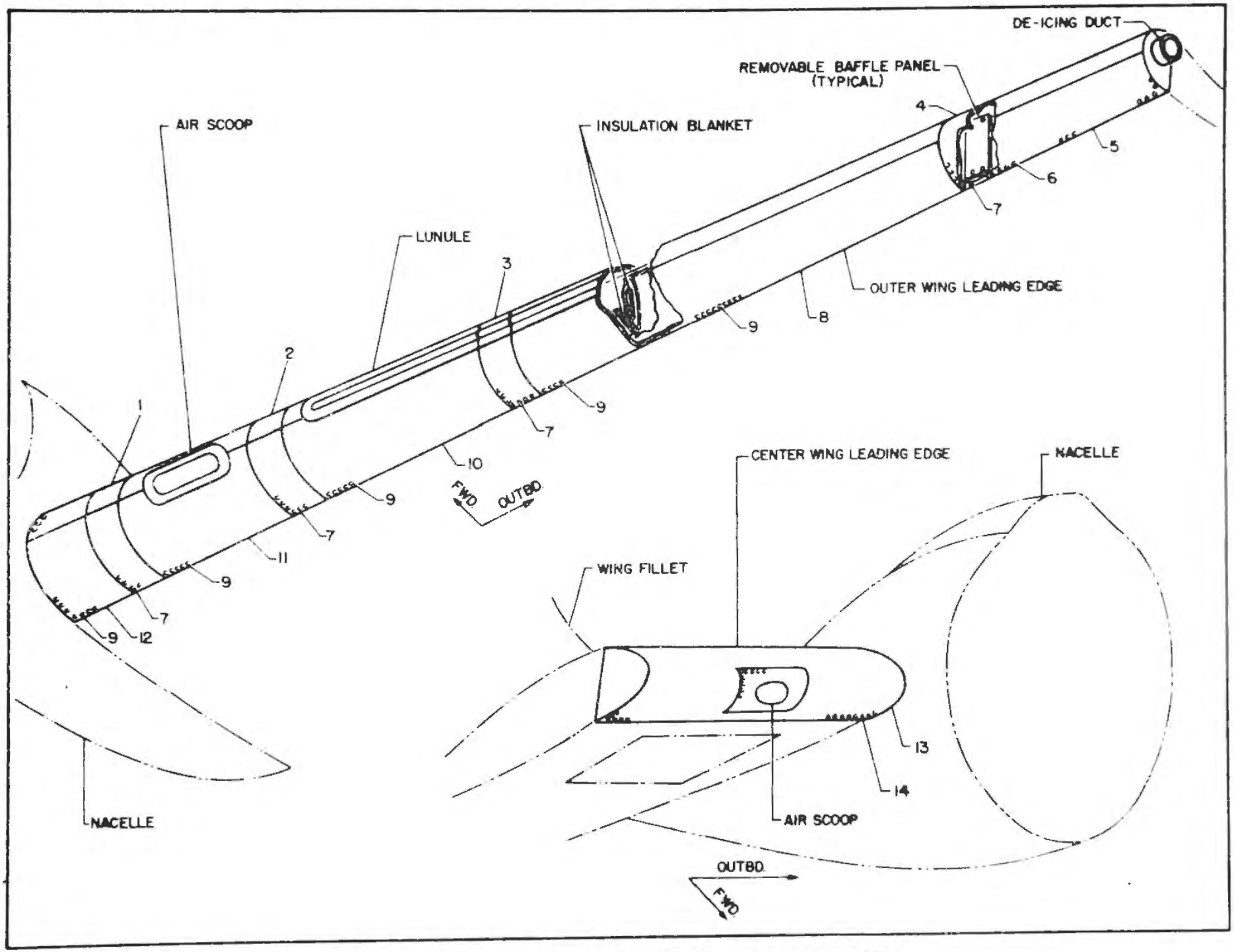


Figure 7. Outer And Center Wing Leading Edges Installed

WING FLAPS AND VARIABLE STABILIZER-GENERAL (See figure 1).

The wing flaps and variable stabilizer are so designed and controlled that when the flaps are lowered to any pre-selected position, the angle of incidence of the horizontal stabilizer is increased proportionately to provide greater flight stability. The flap control is pre-positioning and so arranged that the flaps will automatically assume the position selected by the pilot. The flaps are in four sections, left and right inboard and left and right outboard, and are mechanically interconnected to operate as a unit. Each flap section is actuated by a hydraulically operated cylinder. A flap slat is located above the forward edge of each flap section and is mechanically interconnected with its respective flap. Flap shutter doors are attached to the lower surface of the wing trailing edge and are also mechanically interconnected with the flaps.

A vented overload relief valve is provided in the normal flap hydraulic circuit and permits automatic retraction of the flaps when they are lowered at excessive air speeds, thereby preventing structural damage to the flaps and attaching structure.

A separate hydraulic circuit is provided for emergency extension of the flaps and it does not include the overload protection used in the normal hydraulic circuit.

The variable incidence horizontal stabilizer is operated by an electrically powered actuator attached to the stabilizer rear spar.

WING FLAPS AND VARIABLE STABILIZER OPERATION - GENERAL (See figure 19).

The normal operation of the wing flaps and variable incidence horizontal stabilizer is controlled by the positioning of the flap control lever located on the pedestal in the pilots' compartment. This control, marked "FLAPS", incorporates a pre-selection feature so that the lever may be placed in any desired setting and the flap mechanism will stop when the flaps have reached a corresponding position. Stops are provided on the pedestal so that the control lever may be placed in any one of the following four settings: "UP", "TAKE-OFF", "APPROACH", or "LANDING". Both the "UP" and "LANDING" settings have a three degree spring back to give the pilot "feel" of the control. Hydraulic power for the normal operation is supplied by the closed center system.

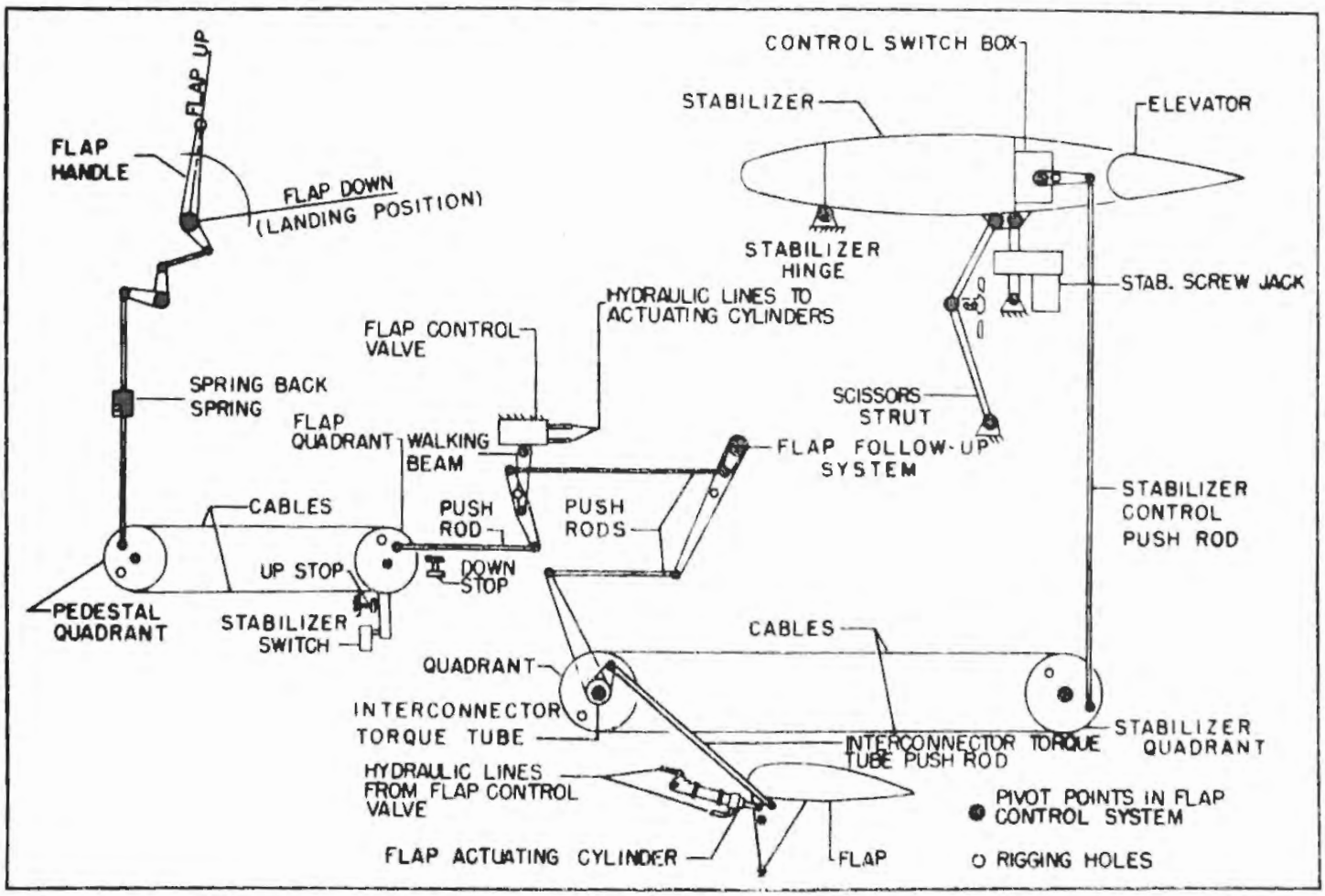


Figure 1. Wing Flaps And Variable Stabilizer Control Schematic

WING FLAPS AND VARIABLE STABILIZER OPERATION - GENERAL (Cont.).

The emergency operation of the wing flaps and variable stabilizer is used when a failure exists in the normal hydraulic system. The emergency operation is controlled by both the "FLAPS" control on the pedestal and the "EMERG. WING FLAP SELECTOR" control on floor on the right side of the co-pilot's seat. The emergency control will only extend the flaps and the normal control must be used to retract them. Hydraulic power for the emergency operation is supplied by the emergency pump through an independent set of lines to the wing flap actuating cylinders.

The variable incidence stabilizer will be operated by the electrically powered stabilizer actuator when the wing flaps are operated by either the normal or emergency systems.

Wing Flaps And Variable Stabilizer Normal Operation (See figure 1).

The normal operation of the wing flaps and variable stabilizer is accomplished by positioning the "FLAPS" control handle in the desired setting. This handle actuates a spring-loaded push-pull rod in the pedestal which in turn moves a quadrant at the base of the pedestal. Cables attached to this quadrant actuate another quadrant mounted on the rear spar under the cabin floor. As the quadrant on the rear spar rotates, a push-pull rod attached to it moves the walking beam on the flap control valve located in the flap follow-up system. With the walking beam moved from its neutral position, poppet valves within the control valve are displaced allowing hydraulic pressure to be applied to either the "up" or "down" side of the wing flap actuating cylinder depending on the setting of the "FLAPS" control lever.

Push-pull rods, which are attached to the inboard ends of each center wing flap, rotate the interconnector torque tube as the flaps move toward the pre-selected setting (see figure 2). This interconnector torque tube is designed to rotate 90 degrees to the flaps 45 degree travel. Attached to the quadrant on the torque tube is another push-pull rod which actuates the linkage in the flap follow-up system. This linkage, in turn, moves the walking beam on the flap control valve toward the neutral position as the flaps travel to the pre-selected setting. When the flaps have reached the pre-selected setting, the walking beam will again be in neutral and both ports to the flap actuating cylinders will be blocked.

A flap position transmitter, which is located near the flap control valve, is also actuated by the flap follow-up system and is electrically connected to the flap position indicator on the instrument panel.

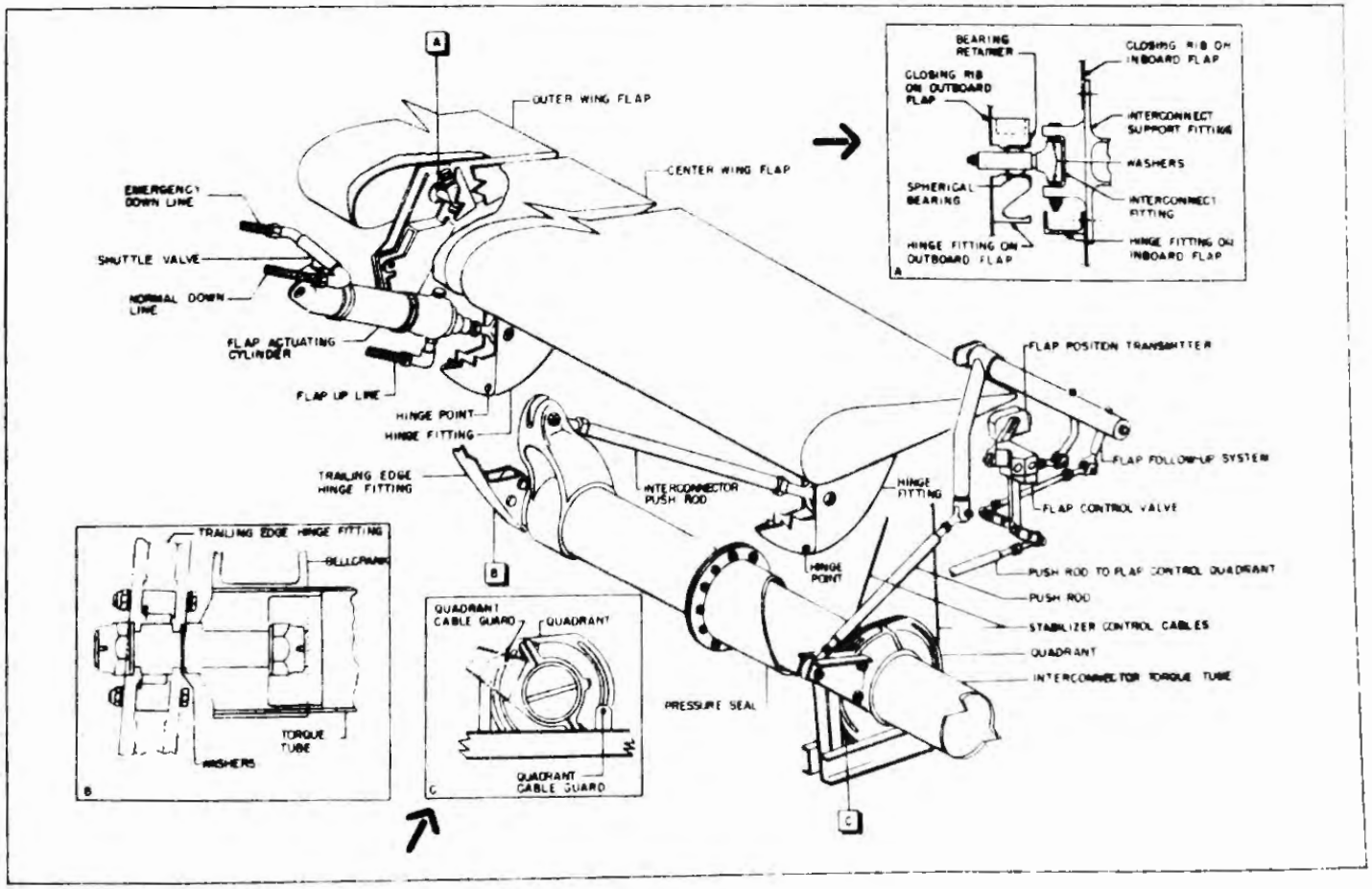


Figure 2. Wing Flap Control Linkage

Wing Flaps And Variable Stabilizer Normal Operation (Cont.).

A cable system, which is attached to the quadrant on the interconnector torque tube, actuates another quadrant at the stabilizer actuator as the torque tube rotates. The rotation of the quadrant at the stabilizer actuator moves an attached push-pull rod which in turn displaces a control arm on the stabilizer control switch box mounted on the rear spar. The control arm, when displaced a pre-determined distance from neutral, actuates either the "up" or "down" micro switch within the control box depending on the direction of flap travel (refer to Section 3 for dimensions of control arm travel). The micro switch will then energize the stabilizer actuator motor and the stabilizer angle of incidence will be changed. The stabilizer actuator quadrant will stop rotating as soon as the flaps reach their pre-selected setting. The stabilizer will continue in its direction of travel until it returns the control arm on the control switch box to a neutral position. The stabilizer movement actually follows the flap movement by only a few seconds. When the control arm reaches a neutral position the micro switch will return to its "off" position, thus de-energizing the actuator motor and stopping the stabilizer travel. Should the micro switch in the control box be late in de-energizing the actuator motor, or fail to operate, limit switches within the actuator itself will stop the motor at either extreme of travel. Should both the micro switch and the limit switch malfunction, then the actuator will be stopped by a mechanical stop.

A micro switch is located on the flap control system quadrant on the center wing rear spar as a safety feature for the stabilizer actuator circuit. This switch is normally closed (circuit completed) when the flaps control handle is in any position other than "UP". When the flaps control handle is in the "UP" position the switch will be mechanically actuated to the open position, breaking the circuit to the down (retract) side of the stabilizer actuator motor, thus making it impossible for a control circuit failure to cause a change of trim when the flaps are up.

All micro switches in the stabilizer control switch box are normally open and must be mechanically actuated to the closed position (circuit completed).

A red warning light is provided on the pilots' instrument panel to warn the pilot when the correct relative position of the flaps and stabilizer is not maintained. This warning light will be illuminated when the stabilizer is one-half degree out-of-phase with the flaps. This one-half degree of stabilizer out-of-phase displaces the arm on the stabilizer control switch box a pre-determined distance from neutral, at which time the arm actuates either one of a second set of micro switches within the control box depending on the direction of flap travel (refer to Section 3 for dimensions of control arm travel). This actuated micro switch completes a circuit which illuminates the warning light.

Wing Flaps And Variable Stabilizer Emergency Operation (See Figure 19).

The wing flaps can be extended by the emergency system, should a failure exist in the normal system. This emergency system will not retract the flaps. The emergency operation of the wing flaps is accomplished by placing the "FLAPS" control lever on the pedestal in the "LANDING" position, and moving the "EMERG. WING FLAP SELECTOR" control handle, located in the floor on the right side of the co-pilot's seat to the "FLAPS DOWN" position; then turning the "EMERG. HYD. PUMP" control switch to the "on" position. The emergency hydraulic pump will then deliver fluid under pressure through a completely independent set of lines to the shuttle valves on the "down" side of the wing flap actuating cylinders and extend the flaps. As soon as the flaps are fully extended the emergency pump should be stopped to avoid pumping the remaining oil from the reservoir through the emergency system relief valve. A check valve provided between the emergency system manifold and the emergency flap selector control valve will hold pressure in the emergency flap down lines when the emergency pump is shut off.

It is possible to place the flaps at any "down" setting past their free floating position by lowering the flaps with the emergency circuit; then stopping the emergency pump and allowing the air load to raise the flaps to the desired setting by placing the "EMERG. WING FLAP SELECTOR" handle in the "NORMAL" position. As soon as the desired setting is reached the control handle is placed in a "neutral" position. This "neutral" position detent is half-way between the "NORMAL" and "FLAPS DOWN" positions and will keep the flaps at the desired setting, even if the emergency pump is operated automatically by the emergency brake system. Some hydraulic fluid will be lost through this operation, if a break exists in the normal system.

The horizontal stabilizer angle of incidence will also be increased through the emergency extension of the flaps and is operated by the rotation of the wing flaps interconnector torque tube as described in "Normal Operation".

WING FLAP CONTROL SURFACES.

The wing flap control surfaces consist of two center wing and two outer wing flaps, a slat mounted above the forward edge of each flap and shutter doors located forward of the flaps on the lower surface of the wing. All of these components are mechanically interconnected so that the operation of the slats and shutter doors is automatic with the wing flap.

Wing Flaps (See figure 3).

There are four wing flaps attached to the trailing edge of the wing, one on each center wing, between stations 54 and 185 and one on each outer wing between stations 185 and 402. These flaps are of all metal construction, and consist of a spar and rib assembly covered with reinforced aluminum alloy sheet and a reinforced formed aluminum alloy leading edge. Each inboard and outboard flap is hinged to the wing trailing edge at three points by streamlined hinge brackets which extend below the lower surface of the wing. All four flaps are interconnected to insure operation as a unit. The two inboard flaps are interconnected by a torque tube and push-pull rods. The inboard and outboard flaps on each side are interconnected by a "T" shaped fitting which is attached to the inboard flap closing rib and extends into a ball and socket joint in the outboard flap closing rib. Each flap is actuated by an individual hydraulic cylinder attached to the top of the flap hinge bracket. The wing flap slats and the shutter doors are mechanically interconnected to the wing flaps. Each inboard and outboard flap is interchangeable between airplanes.

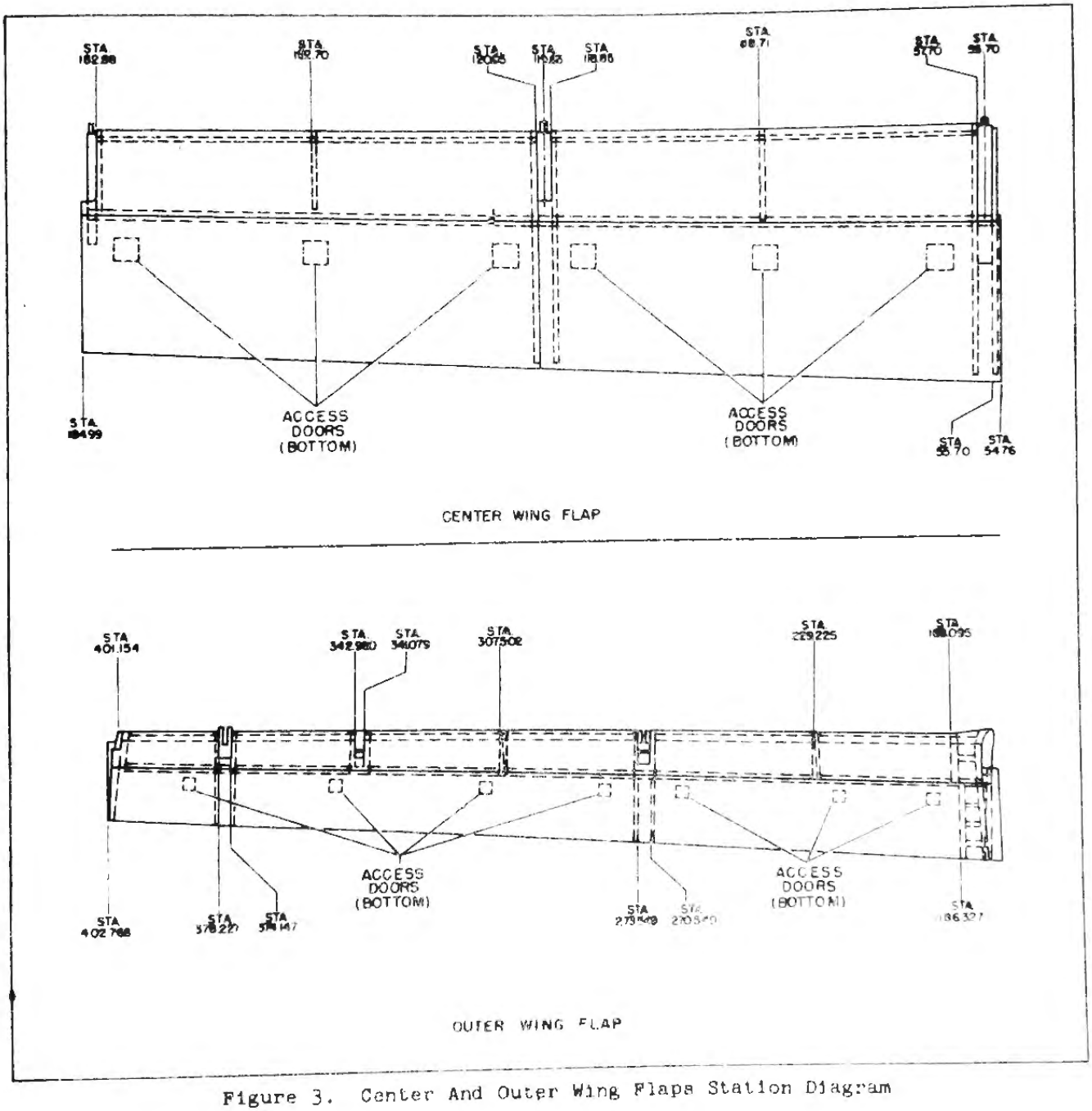


Figure 3. Center And Outer Wing Flaps Station Diagram

Wing Flap Shutter Doors (See figure 4).

There are two wing flap shutter doors for each inboard flap and three shutter doors for each outboard flap. These shutter doors are attached to the lower surface of the wing trailing edge by piano type hinges and are mechanically connected to the flaps. The shutter doors are of all metal construction and consist of a spar and formers covered with aluminum alloy sheet on the lower surface only. When the flaps are in the "up" position, the shutter doors are closed and provide a smooth flow of air across the lower surfaces of the wing and flap. As the flaps are lowered to the down position, the shutter doors open to permit the air to flow around the flap slats. This increases the effectiveness of the flaps in the down position by reducing turbulence in the air stream. The shutter doors are held in the "open" position by tension springs, located above the doors, when the flaps are extended. They are pushed to the "closed" position by telescoping tubes which bottom in each other as the flaps near the "up" position. All shutter doors are interchangeable between airplanes.

Wing Flap Slats (See figure 4).

Four wing flap slats are attached to the wing trailing edge, one above each inboard and outboard flap. They are located between the trailing edge of the wing and the top surface of the flap leading edge, and are mechanically connected to the flaps. The function of the slats is to increase the maximum lift of the wing by controlling the flow of air over the flaps when they are in the down position. The slats are of the conventional rib and spar construction and are covered by formed aluminum alloy sheet. The inboard flap slats are hinged to the wing trailing edge by three hinge fittings which also serve as attaching points for the slat actuating rods. The outboard flap slats are hinged to the wing trailing edge by five hinge fittings, three of which serve as attaching points for the slat actuating rods. The slats are interchangeable between airplanes.

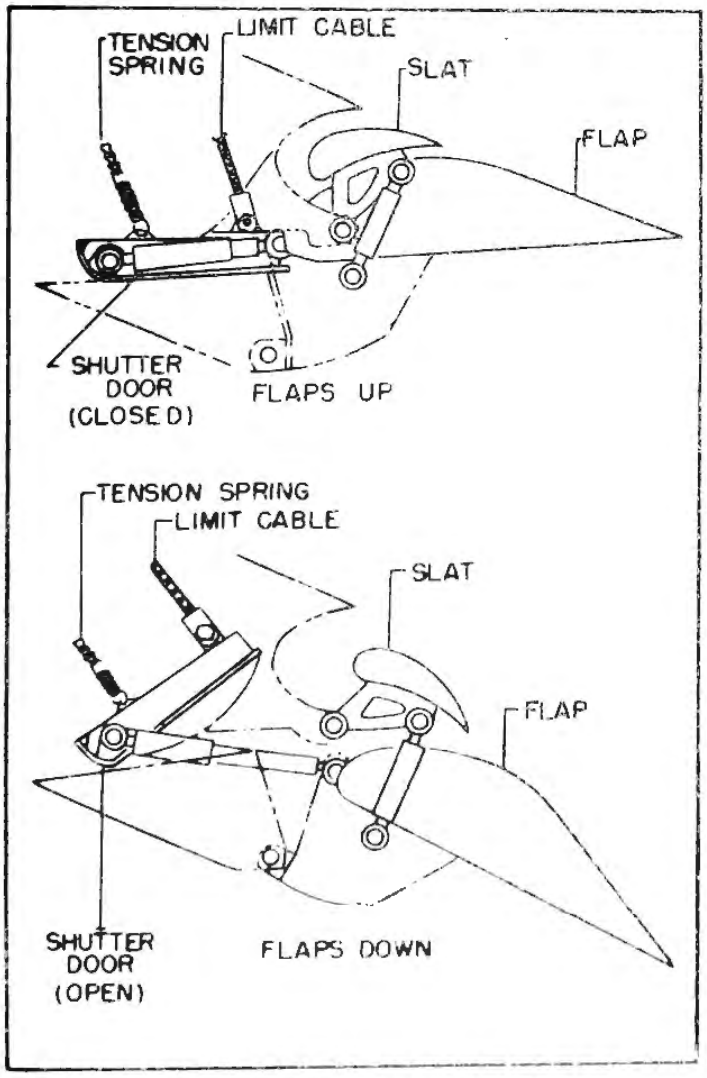


Figure 4. Wing Flap Position Schematic

WING FLAP HYDRAULICS - GENERAL (See figure 17).

Two separate hydraulic circuits, a normal and an emergency, are provided to actuate the wing flaps. The normal hydraulic circuit will either extend or retract the flaps while the emergency hydraulic circuit will only extend the flaps. The normal hydraulic circuit is supplied from the closed center system and directs hydraulic pressure to both the "up" and "down" sides of the flap actuating cylinders. The emergency hydraulic circuit is connected to the emergency hydraulic system and directs hydraulic pressure through a completely independent set of lines to the "down" side only of the flap actuating cylinders.

Normal Wing Flap Hydraulic Circuit. (See figure 17).

The normal wing flap hydraulic circuit is supplied from the closed center hydraulic system and consists of a flap control valve, a vented flap load relief valve, a thermal relief valve, two flow regulators, a check valve, a one-way restrictor valve, and four wing flap actuating cylinders. All of these components, except the flap actuating cylinders, are located in the belly of the fuselage aft of the center wing rear spar and are accessible through the rear spar access hatch #86.

The closed center hydraulic system supplies pressure through the check valve and flow regulator to the pressure side of the flap control valve. The check valve is a special no-leak type check valve used to prevent loss of hydraulic pressure from the flap circuit. The flow regulator limits the flow of fluid to the flap control valve thereby regulating the time for extending or retracting the wing flaps. The flap control valve directs hydraulic fluid to either the flaps "down" line or flaps "up" line when its walking beam is moved fore or aft of neutral by the "FLAPS" control on the pedestal.

A one-way restrictor valve is installed in the flap "up" line to restrict the speed of the flap extension, but is free flowing for flap retraction. A cross type "AN" fitting is also installed in the flaps "up" line downstream of the restrictor valve and acts as a manifold in directing fluid to the "up" side of the flap actuating cylinders in both wings and to the thermal relief valve. This thermal relief valve relieves excess thermal pressure in the flaps "up" line into the return line to the reservoir.

Another flow regulator is installed in the flaps "down" line from the flap control valve and is used to regulate the return flow of fluid from the actuating cylinder thereby controlling the speed of the "up" travel of the wing flaps. A "T" shaped "AN" fitting is also installed in the flaps "down" line downstream from the flow regulator to serve as a manifold in directing fluid to shuttle valves on the "down" side of the flap actuating cylinders in the left and right wings. Between this fitting and the flow regulator is another "T" shaped "AN" fitting which connects the flaps "down" line with the vented flap load relief valve.

This valve, which is vented to the cabin atmosphere, discharges excess pressure from the flaps "down" line into the return line. This return fluid by-passes the flap control valve. This valve will open and relieve excess pressure in the flaps "down" line when the air load on the wing flaps becomes excessive. This relieving permits the wing flaps to partially retract, if down, or prevents them from lowering, if being extended. Thus it serves as an overload protection and prevents structural damage to the wing flaps and supporting structure, should the flaps be lowered at excessive air speeds. See figure 19 for flap hydraulics schematic.

During normal operation of the wing flaps, return fluid from the "down" and "up" sides of the actuating cylinder is returned through the flap control valve and the flap return line to the main hydraulic system reservoir. Refer to Chapter 16 for a description of the closed center hydraulic system.

Emergency Wing Flap Hydraulic Circuit. (See figure 17).

The emergency wing flap hydraulic circuit is completely independent of the normal wing flap hydraulic circuit and is used for emergency extension of the flaps only. The wing flaps will be lowered the same number of degrees by the emergency circuit as they are by the normal circuit. The emergency flap hydraulic circuit consists of a check valve, a three-way selector valve, and a separate set of lines to the shuttle valves on the wing flap actuating cylinders. Hydraulic pressure is supplied to the emergency wing flap circuit from the emergency hydraulic system, through a check valve, to the three-way selector valve. When this selector valve, located on the pilots' compartment floor on the right side of the co-pilot's seat, is placed in the "FLAPS DOWN" position, hydraulic pressure from the emergency system will be transmitted through the emergency wing flap "down" lines to the shuttle valves on the "down" side of the actuating cylinders, extending the wing flaps.

Return fluid from the "up" side of the actuating cylinders is returned through the normal flap "up" lines to the flap control valve and then to the main hydraulic system reservoir. The emergency hydraulic system pump must be turned "off" as soon as the flaps are full down so as to avoid pumping the remaining fluid from the reservoir through the emergency hydraulic system relief valve. The check valve, which is upstream from the emergency three-way selector valve, will hold pressure in the emergency flap circuit after the pump is turned "off". This valve will be by-passed and fluid will go back to the reservoir through the return line when the selector is placed in the "NORMAL" position.

In order to establish return from the "up" side of the actuating cylinders during emergency extension the normal wing flap control on the pedestal must be in the "DOWN" position while the flaps are being lowered by the emergency system. After flaps reach the desired position, the "EMERG WING FLAP SELECTOR" can be moved to neutral position which blocks the emergency extension pressure line and holds the flaps in that position.

Emergency Wing Flap Hydraulic Cir[illegible]

CAUTION

It must be remembered that after flaps have been extended by pressure from the emergency flaps down line, the shuttle valves will remain shifted until flow from the normal flaps down system occurs. Therefore, before the flaps can be retracted the first time after emergency lowering, the "EMERG. WING FLAP SELECTOR" must be in the "NORMAL" (forward position) so flow from the "down" side of the actuating cylinders can pass back through the valve to return.

All return fluid is now available to the emergency pump, even though the engine pump supply is exhausted. Refer to Chapter 12 for a description of the emergency hydraulic system.

Flap Control Valve (See figure 5).

The flap control valve is located in the flap [illegible] system at station 518 under the cabin floor and is accessible through the fuselage [illegible] access hatch. The control valve is mounted to the cabin floor structure with four screws safety-wired together in sets of two. The valve is used to control the direction of hydraulic pressure for raising and normal lowering of the wing flaps. However, for emergency lowering of the wing flaps the control valve is positioned the same as for normal lowering to provide a return for the emergency hydraulic system. It is a four way poppet type valve with a walking beam attached to the base of the valve body. This walking beam actuates the poppet valves within the control valve, and is attached to the flap control linkage

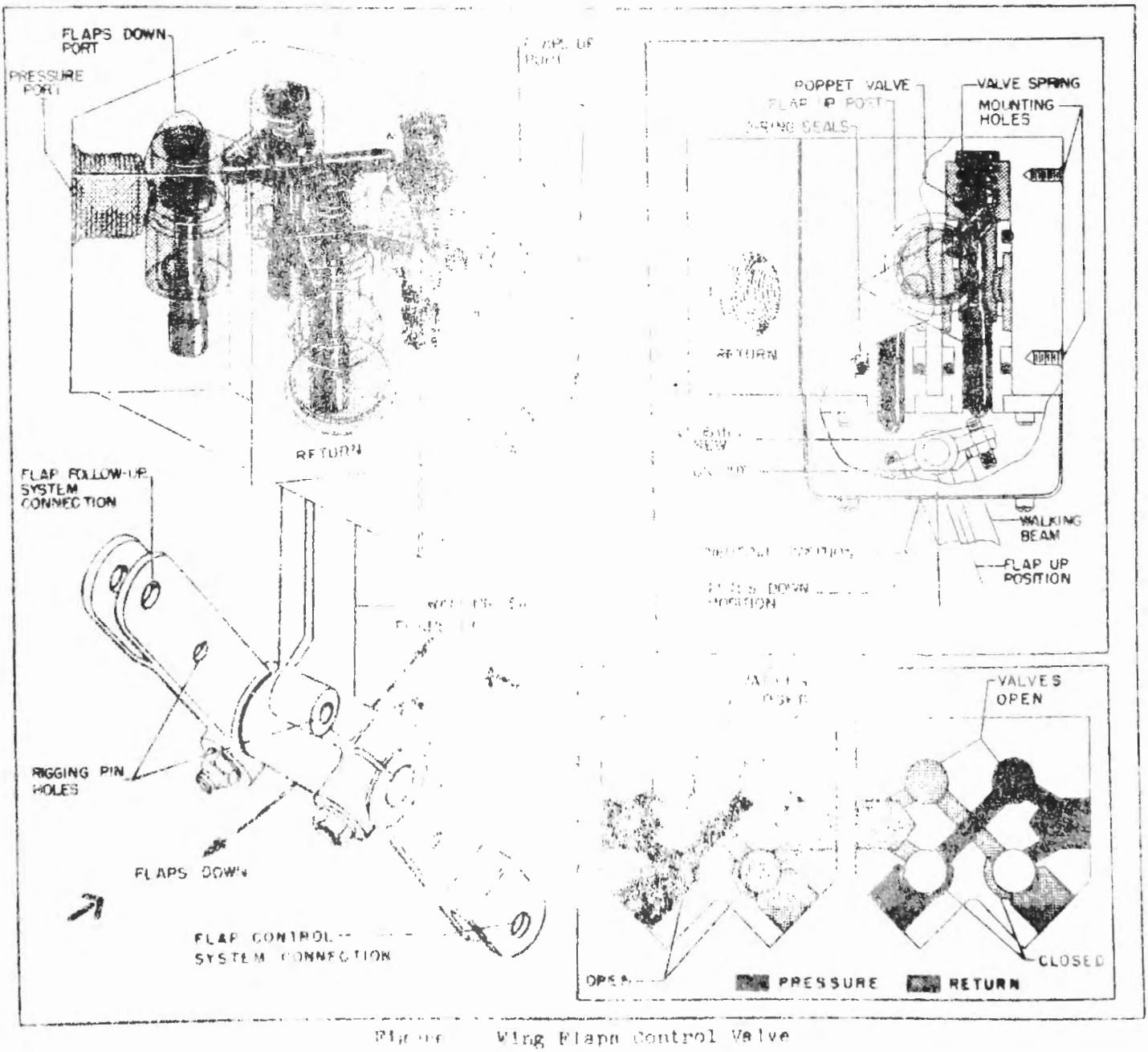


Figure Wing Flaps Control Valve

Flap Control Valve (Cont.).

at the lower arm connection and to the flap follow-up system at the upper arm connection.

With the wing flaps "up", the placing of the "FLAPS" control on the pedestal in any position other than "UP" will move the walking beam forward of neutral, opening the two forward poppet valves within the control valve. The opened poppet valve at the "PRESSURE" port will direct hydraulic pressure to the flaps "down" line, while the opened poppet valve at the "RETURN" port will permit return fluid from the flaps "up" line to be returned to the main hydraulic reservoir. When the "FLAPS" control is placed in the "UP" position, with the flaps in any position other than "up", the walking beam will be moved aft of neutral and will open the two aft poppet valves within the control valve. The opened poppet valve at the flaps "up" port will permit hydraulic pressure to enter the flaps "up" line, while the opened poppet valve at the flaps "down" port will permit return fluid from the flaps "down" line to be returned to the reservoir. The walking beam will be returned to neutral from either the forward or aft position by the flap follow-up system when the flaps reach the position which corresponds to setting of the "FLAPS" control handle.

The flap control valve is rigged with the walking beam in a neutral position and the "FLAPS" control lever on the pedestal slightly lower than the "UP" position. With this arrangement, the control valve is open slightly when the "FLAPS" control is in the full "UP" position. This is done to pressurize the flaps "up" line and prevent any tendency of the flaps to droop.

Refer to index of this chapter for procedure on adjusting the flap control valve.

Flow Regulators (See figure 6).

Two flow regulators are installed in the normal flap hydraulic circuit to restrict the flow of fluid in one direction and permit free flow in the reverse direction. The regulators consist of a regulator body, a piston, a compression spring, two "O" ring seals, and a sleeve over the regulator body. The tubular regulator body is partially drilled from each end. Two rows of holes are drilled through the sides of the regulator body, one row on either side of the internal wall left by partially drilled ends. A small orifice hole is drilled through the center of this internal wall. Installed inside of the regulator body is the compression spring and piston. The piston has an orifice hole drilled in the head and two slots in the skirt, and is installed with the skirt end against the spring. The piston is held in place with a lock ring. The sleeve, which covers the two rows of holes and the passage between the holes, is sealed by two "O" ring seals, one at either end of the sleeve. The sleeve is also held in place by a lock ring.

Hydraulic fluid entering the regulator flows through the orifice in the piston head, then out the slots in the piston skirt. From the slots in the piston skirts, the fluid flows into the passage between the regulator body and sleeve through the row of metering holes, and back into the valve body through the row of free flow holes, and then out of the regulator. The hydraulic fluid entering the regulator in addition to flowing through the orifice also forces the piston back, partially closing the row of metering holes, thereby regulating the flow of fluid through the regulator. The restriction of the first row of metering holes by the piston is proportionate to the pressure of hydraulic fluid entering the regulator. The small orifice hole in the internal wall is provided to prevent a hydraulic lock, should a surge of pressure force the piston far enough to completely close the metering holes. This regulating of the hydraulic pressure determines the speed at which the flaps are raised or lowered (refer to Series 3 for flap travel speed). Reverse flow of fluid through the regulator is unrestricted and free flowing.

An arrow on the regulator name plate denotes the direction of the regulated flow. One regulator is installed in the flap pressure line between the check valve and the flap control valve with its arrow pointing downstream toward the flap control valve. The other regulator is installed in the flap "down" line from the flap control valve with its arrow pointing upstream toward the flap control valve.

These regulators normally will not require any servicing between overhaul periods, but if leaks occur or the regulators malfunction, replace with serviceable units. No attempt should be made to adjust or disassemble a regulator, for it is possible to assemble it incorrectly, resulting in malfunctioning of the flap system.

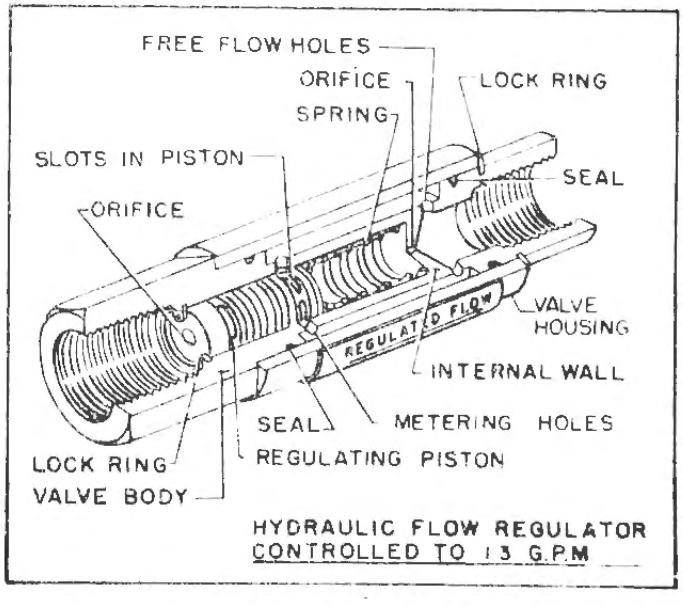


Figure 6. Hydraulic Flow Regulator

Thermal Relief Valve (See figure 7).

A thermal relief valve is provided in the normal wing flap hydraulic circuit to relieve excessive pressure in the flaps "up" line due to thermal expansion of hydraulic fluid. This valve is located under the cabin floor near the flap control valve and is accessible through the fuselage rear spar access hatch. The pressure side of the valve is connected to a line from the cross-type "AN" fitting that serves as a manifold in the flaps "up" line. The return side of the valve is connected to the flap return system, and any fluid relieved by the valve by-passes the flap control valve. A pressure adjusting screw and lock nut is located on the opposite end of the pressure port and is used for bench adjustment of the valve's cracking pressure setting (refer to Section 3 for data on valve's settings). Both the adjusting screw and lockwasher are safetied. No attempt should be made to adjust this thermal relief valve. It will normally not require servicing between overhaul periods, but if leaks should occur or the valve malfunctions, replace it with a serviceable unit.

Vented Flap Load Relief Valve (See figure 8).

The flap load relief valve is located at station 505 near the flap control valve and is accessible through the belly rear spar access hatch. It is mounted to a transverse cabin floor beam by three bolts. The valve body houses a spring-loaded main valve, a spring-loaded poppet valve, a pressure port, a return port, and an adjusting screw used to bench set the pressure at which the valve will crack open. The pressure port of the valve is connected to the flaps "down" line of the normal flap hydraulic circuit and the return port is connected to the flap return line.

The function of this load relief valve is to provide automatic retraction of the wing flaps by opening and allowing hydraulic pressure to be relieved from the flaps "down" line should the flaps be lowered at excessive air speeds or in case of heavy gust conditions, thus preventing overloading of the wing flaps and supporting structure. The valve is vented to the cabin atmosphere through a vent hole in the top of the valve, thus making the cracking pressure always the same regardless of back pressure in the return port. This valve also acts as a thermal relief for the flaps "down" line.

This valve normally requires no servicing between overhaul periods, but if leaks occur or the valve malfunctions, replace it with a serviceable unit. No attempt should be made to adjust the cracking pressure.

Wing Flap Emergency Control Valve. (See figure 9).

The wing flap emergency control valve is located under the pilots' compartment floor with its control handle extending up through a slot in the floor on the right side of the co-pilot's seat. It is identified by a placard "EMERG. WING FLAP SELECTOR" on the floor on the outboard side of the handle. This valve is a three-way selector type valve and is used to control the emergency extension of the wing flaps.

The control valve consists of a valve body which houses two spring loaded poppet valves, a camshaft, and three ports for connecting the emergency system hydraulic lines. Integral

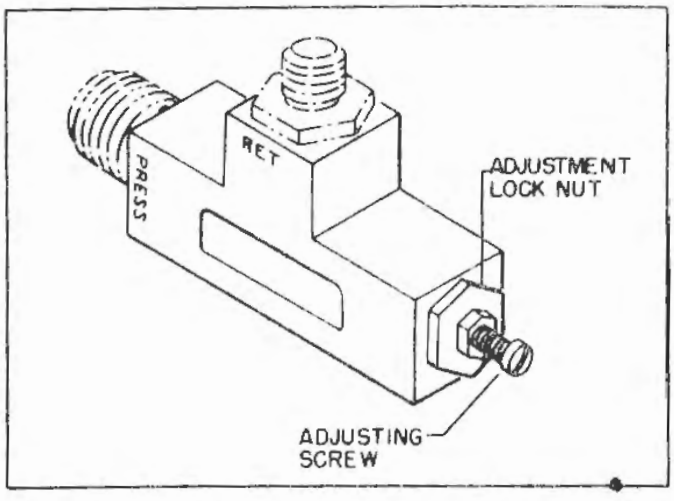


Figure 7. Hydraulic Thermal Relief Valve

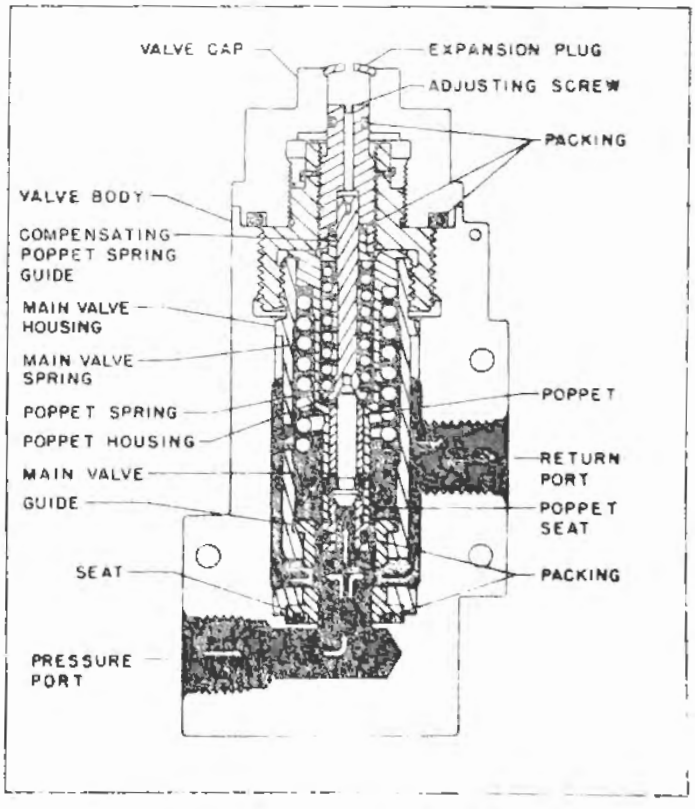


Figure 8. Flap Load Relief Valve

Wing Flap Emergency Control Valve (Cont.).

cam stops limit the rotation of the camshaft to 45 ± 3 degrees either side of neutral. When the mark on the external end of the camshaft lines up with the mark on the camshaft retainer, the valve will be in a neutral position. Looking at the shaft end of the valve, the cylinder port (emergency down) will be connected to return when the shaft is rotated 45 degrees clockwise. Rotating the shaft 45 degrees counterclockwise from neutral will connect the cylinder port to pressure. This valve, when installed in the emergency wing flap hydraulic circuit, utilizes the two positions on either side of neutral. These positions are identified by placards on the pilots' compartment floor, "NORMAL" being at the forward end of the control handle slot and "FLAPS DOWN" at the aft end of the slot. In the "NORMAL" position the cylinder port is connected to return, while in the "FLAPS DOWN" position the cylinder port is connected to pressure. The emergency control valve handle attached to the camshaft is held in the "NORMAL" position by the detent plate to prevent accidental lowering of the wing flaps.

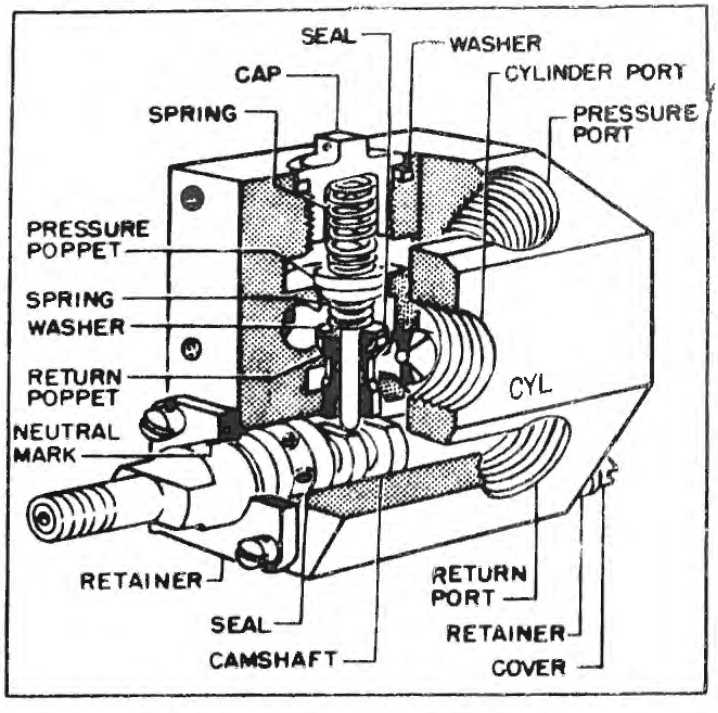


Figure 9. Wing Flap Emergency Control Valve

Normally this valve will not require any servicing between overhaul periods, but if leaks occur or the valve malfunctions, replace it with a serviceable unit. Do not attempt to adjust it.

Normal Hydraulic Circuit Check Valve (See figure 10).

A special "no leak" check valve is used in the normal hydraulic circuit to prevent loss of pressure due to reverse flow of fluid from the circuit. It is located near the flap control valve in the flap pressure line and is accessible through the fuselage rear spar access hatch. It is installed in the pressure line with the arrow on the body pointing downstream toward the flap control valve. An "O" ring seal, within the valve, serves as the piston seat to assure a positive seal against loss of pressure, thus preventing flap droop. This valve will normally not require servicing between overhaul periods, but if leaks occur or valve malfunctions, replace with a serviceable unit.

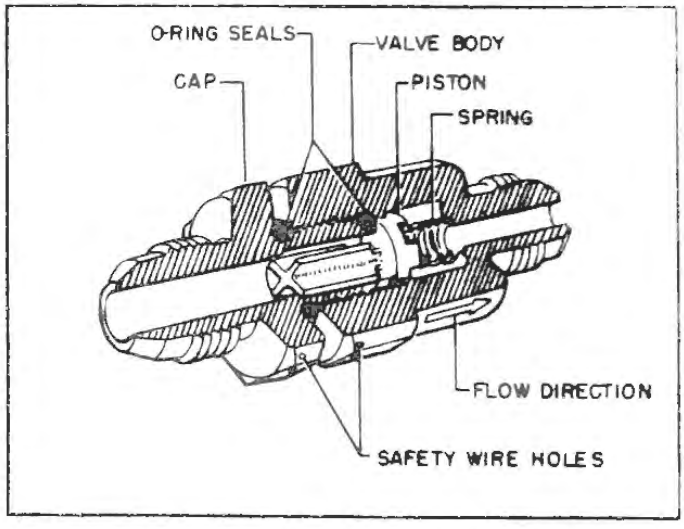


Figure 10. Normal Hydraulic Circuit Check Valve

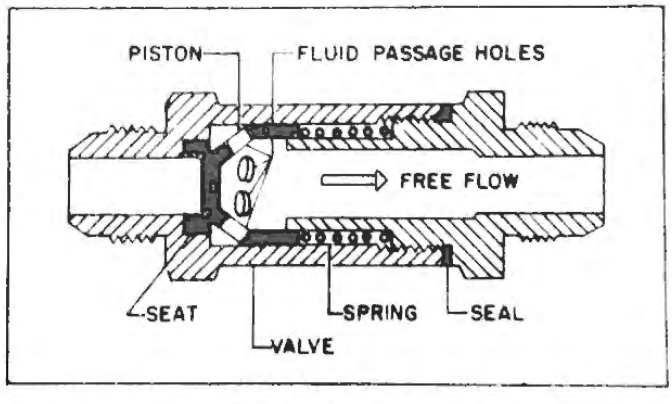


Figure 11. Emergency Hydraulic Circuit Check Valve

Emergency Hydraulic Circuit Check Valve. (See figure 11).

A conventional spring loaded check valve is used in the emergency hydraulic circuit to prevent loss of pressure due to reverse flow of fluid from the circuit. It is located just aft of the emergency wing flap control valve under the pilots' compartment floor in the emergency pressure line and is accessible through the right side pressure panel in the nose wheel well. It is installed in the emergency pressure line with the arrow on the body pointing downstream toward the emergency wing flap control valve. This valve will normally not require servicing between overhaul periods, but if leaks occur or valve malfunctions, replace with a serviceable unit.

Wing Flap Actuating Cylinders (See figure 12).

Four hydraulically operated cylinders are used to extend and retract the wing flaps, one being used for each flap section. These cylinders are located within the trailing edges of the wings, with the center wing flap cylinders at wing station 120 and the outer wing flap cylinders at wing station 272.5. The heads of the cylinders are attached to the trailing edge hinge fittings while the piston rod ends are attached to the flap hinge fittings. A shuttle valve is attached to the upper end of the cylinder and is used to direct fluid from either the normal or emergency "down" lines connected to it into the "down" side of the cylinder. The normal flaps "up" hydraulic line is connected to the lower end of the cylinder. Flexible tubing is used to connect the cylinder and shuttle valves to the hydraulic lines on the aft side of the wing rear spars. The bottoming of the piston in the cylinder at the retracted end serves as the "up" stop for flaps, while the bottoming of the piston in the extended end serves as the emergency "down" stop. The normal "down" stop is one-half inch from the bottomed emergency "down" stop. Two red colored bleeder plugs are incorporated in each flap cylinder and are used to bleed the cylinder on each side of the piston. The cylinder head attachment and the piston rod end fitting each have a lubrication fitting, and the cylinder barrel has an oiler plug used to lubricate the flet piston rod wiper ring. Refer to Chapter 14 for lubrication instructions. The cylinder's retracted length should be as specified on the cut-away view (figure 12). The rod end may be adjusted according to dimensions shown on figure 12 if the retracted length requires changing for rigging purposes. This cylinder normally requires no servicing between overhaul periods, but if leaks occur or the cylinder malfunctions, replace with a serviceable unit.

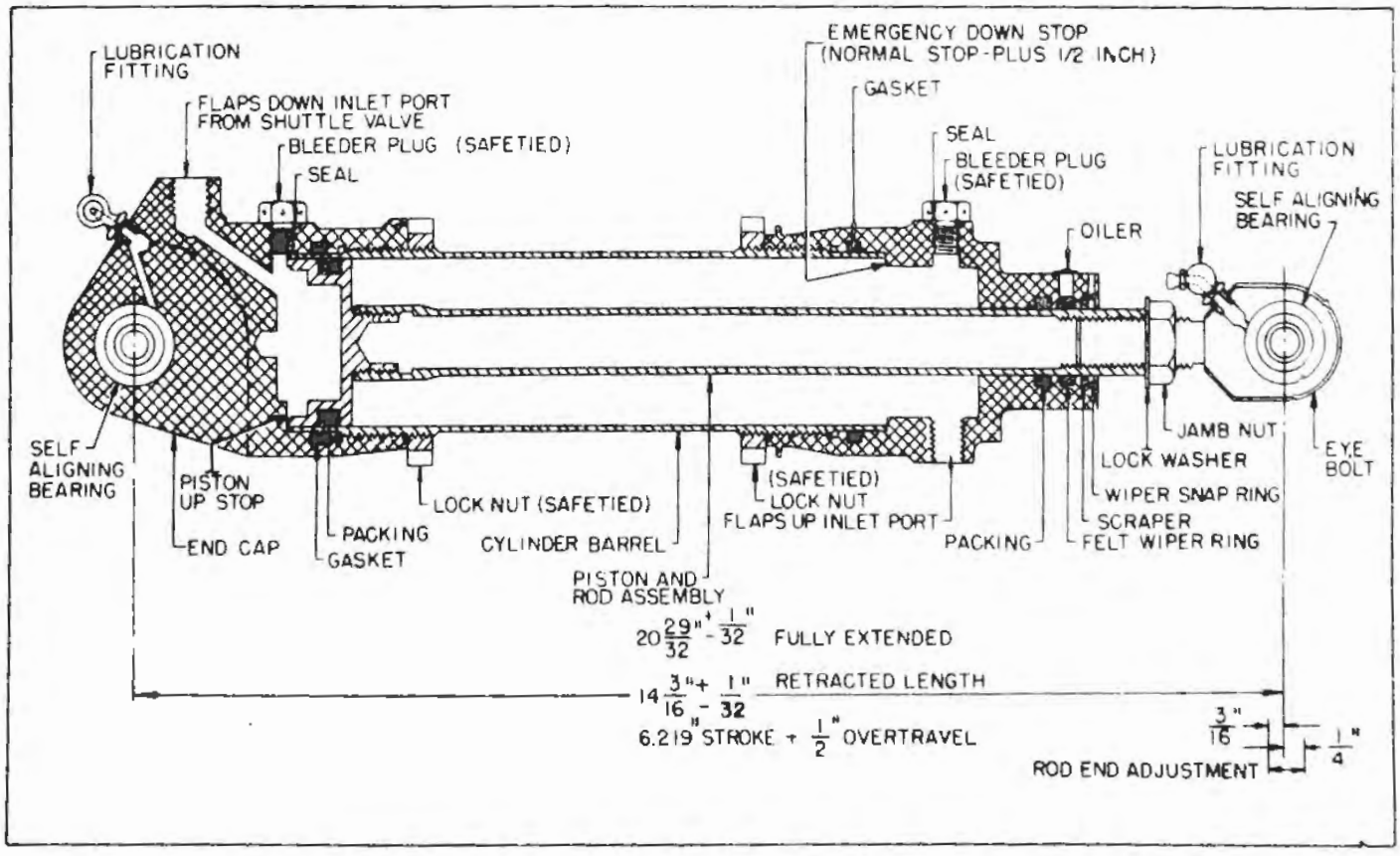


Figure 12. Wing Flap Actuating Cylinder

Shuttle Valves (See figure 13).

A shuttle valve is attached to the upper end of each wing flap actuating cylinder at the "down" side port. These valves are used to direct hydraulic fluid from either the normal or emergency circuits into the "down" side of the flap actuating cylinders. Each valve consists of a valve body, a spool shaped piston with flutes, a spring loaded steel ball, two inlet ports and one outlet port, and two "O" ring seals.

Hydraulic pressure applied through the normal circuit inlet port of the shuttle valve forces the piston against the emergency circuit port, sealing off that port. As the piston is forced against the emergency circuit port, the spring loaded ball drops into one of the flutes on the piston and holds it in this position allowing hydraulic pressure to be applied against the "down" side of the flap actuating cylinder. When hydraulic pressure is applied through the emergency circuit inlet port, the piston will be reversed in position and seal off the normal circuit inlet port. An "O" ring seal, located at each inlet port, provides a leak proof seat for the piston. The piston will move from one position to the other only when hydraulic pressure is applied against it from one of the inlet ports. Thus, when the wing flaps are raised, return fluid from the "down" side of the flap actuating cylinders will be returned through either the normal or emergency circuit lines depending on the circuit used to lower the wing flaps.

These shuttle valves normally will not require servicing between overhaul periods, but if leaks occur or a valve malfunctions, replace with a serviceable unit. This valve is non-adjustable.

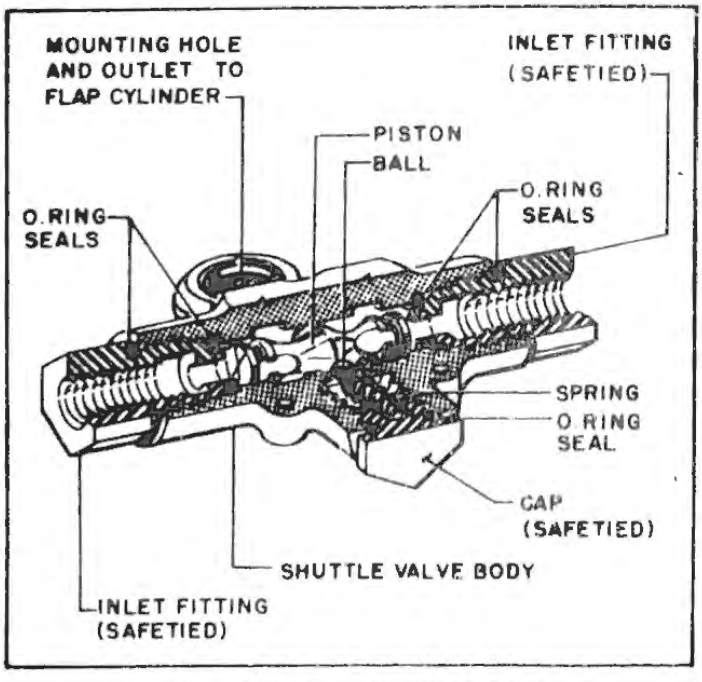


Figure 13. Shuttle Valve.

One Way Restrictor Valve (See figure 13A).

The one-way restrictor valve is located in the flaps up line just downstream from the flap control valve and is accessible through the fuselage rear spar access hatch. It is installed in the flaps up line with the free flow arrow on the valve body pointing downstream away from the flap control valve.

This valve consists of a body and threaded cap sealed with an "O" ring, a spring, and a cone with free flow holes and an orifice in its head. Return fluid from the "up" side of the flap actuating cylinders passes through the valve to the flap control valve and is restricted by the .055 inch orifice in the cone, thus slowing down the extension of the flaps. Hydraulic fluid under pressure from the flap control valve enters the restrictor valve in the free-flow direction. Pressure in this direction depresses the spring-loaded cone, thus permitting the fluid to pass through the free-flow holes in the cone head and into the lines to the "up" side of the flap actuating cylinders.

Normally this restrictor valve will not require servicing between overhaul periods, but if leaks should occur or the valve malfunctions, replace with a serviceable unit.

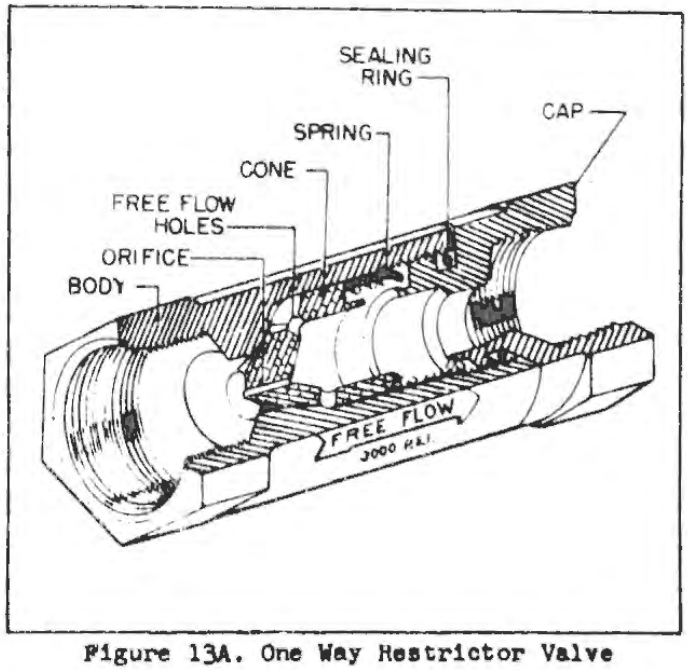


Figure 13A. One Way Restrictor Valve

VARIABLE STABILIZER - GENERAL (See figure 21).

The horizontal stabilizer on this airplane is the variable incidence type and is so designed and controlled that when the wing flaps are extended to any "down" position, the horizontal stabilizer's angle of incidence will be increased proportionately to the flap setting. This proportional increase of the stabilizer angle of incidence to the various wing flap "down" positions contributes to greater safety and flight stability during flap operation by minimizing trim changes resulting from flap movement.

The horizontal stabilizer's angle of incidence is changed by an electrically operated screw jack actuator attached to the center line of the stabilizer rear spar. Control cables connected to the quadrant on the wing flap interconnector torque tube mechanically actuate a control switch box on the stabilizer rear spar, which in turn energizes and controls the actuator. The horizontal stabilizer is hinged at two points on its front spar to the fuselage. These hinge points on the front spar are aft of the stabilizer leading edge; therefore, when the trailing edge goes down the leading edge goes up, resulting in an increase of angle of incidence. In this description and the following descriptions on operation and component parts, any reference to the retraction of the stabilizer actuator will mean that the rear spar is lowered, increasing the stabilizer angle of incidence. Likewise, any reference to the extending of the stabilizer actuator will mean the raising of the rear spar, resulting in a decrease of stabilizer angle of incidence. A scissors strut is attached to the rear spar and to the fuselage to serve as a safety measure in the event of structural failure of the actuator screw jack (refer to description of scissors strut for further information). For a further description of the horizontal stabilizer structure refer to Chapter 5.

Stabilizer Scissors Strut (See figure 14).

A stabilizer scissors strut is attached to the rear spar of the horizontal stabilizer and to the fuselage structure to serve as a safety measure in the event of structural failure of the stabilizer actuator screw jack. This scissors strut is made of steel tubing welded to hinge fittings at the points of attachment to the rear spar and to the fuselage. It is also hinged at the middle where the upper half of the assembly attaches to the lower half. Thus it acts as a scissors when the stabilizer travels up and down. One end of this center hinge fitting is shaped in the form of an arrow and is used to lock the scissors strut to the fuselage when the strut is in the engaged position. A 3/16 inch rigging pin hole which is provided in this center hinge fitting and the lock assembly is used in adjusting the scissors strut and the stabilizer actuator. A 1/4 inch hole adjacent to this 3/16 inch hole is not to be used in rigging. The scissors strut length is adjustable at the center hinge fitting to facilitate installation. Also, the washers on either side of the hinge fittings, at the points of attachment at the stabilizer rear spar and at the fuselage, may be moved from one side of the hinge fittings to the other as necessary, at installation of scissors strut. Refer to Chapter 14 for lubrication of scissors strut.

The scissors strut will automatically lock itself to the fuselage structure should a structural failure occur in the screw jack of the stabilizer actuator in flight. This automatic locking action is caused by air loads on the stabilizer surface, which will raise the aft end of the stabilizer and engage the scissors lock, positioning the stabilizer in a slightly lower than "faired-in" position. The scissors strut lock can not be disengaged until the aircraft is on the ground and air loads are removed from the stabilizer. Should a failure occur in the screw jack while the stabilizer is being operated, the red warning light on the pilots' instrument panel would automatically be illuminated.

CAUTION

Do not attempt to operate the stabilizer actuator with the scissors strut lock engaged. This would result in damage to the fuselage structure and to the actuator.

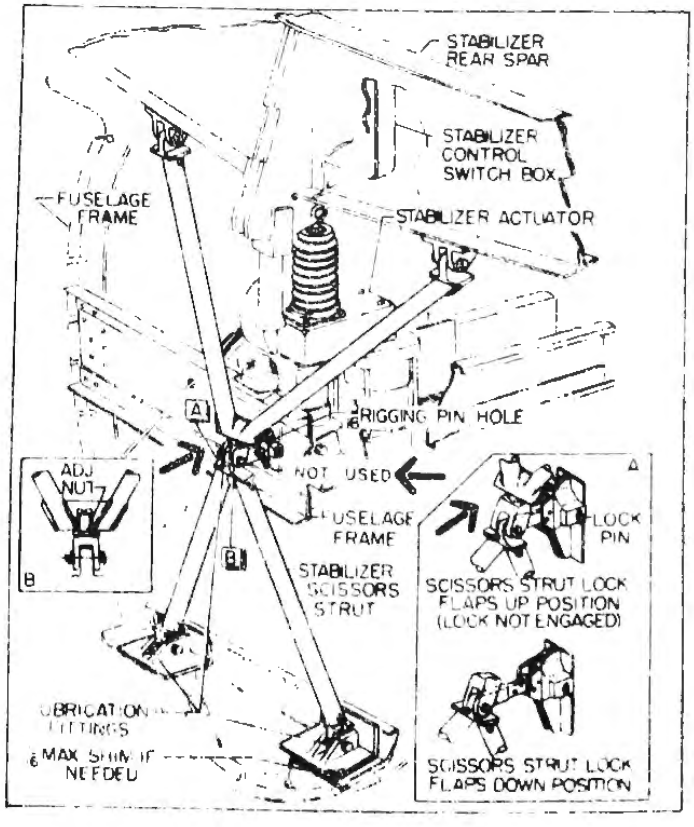


Figure 14. Stabilizer Scissors Strut

VARIABLE STABILIZER ELECTRICAL SYSTEM - GENERAL.

The variable stabilizer actuator electrical system consists of the following major components: a retract safety switch, an extend power relay, a retract power relay, a field control relay, a stabilizer control switch box, a stabilizer actuator, and a red warning light. Included in the electrical system in the stabilizer actuator is a compound motor having two series fields and a follow-up rheostat in series with a shunt field, two limit switches, a brake-clutch coil, a radio noise filter, and a thermo protector.

VARIABLE STABILIZER ELECTRICAL SYSTEM OPERATION. (See figure 15).

Power for the stabilizer actuator electrical system is supplied by the 28 volt d-c forward distribution bus through three circuit breakers. The positioning of the "FLAPS" control to any position other than "UP" will actuate the flap control quadrant on the rear spar and close the retract safety switch attached to the quadrant support bracket. When flap movement starts toward the pre-selected position, the flap interconnector torque tube will actuate the stabilizer control cables. These cables in turn move a push rod connecting the stabilizer control quadrant with the control arm on the switch box. The displacing of the control arm closes the stabilizer actuator "down" switch within the control switch box. The closing of this switch will energize the circuit to the stabilizer actuator limit switch, through the limit switch to the retract field control and retract power control relay coils, energizing the relays. With these two relays closed, a circuit is completed to the stabilizer actuator brake-clutch coil, follow-up rheostat and shunt field winding, back through the retract field control relay and the stabilizer

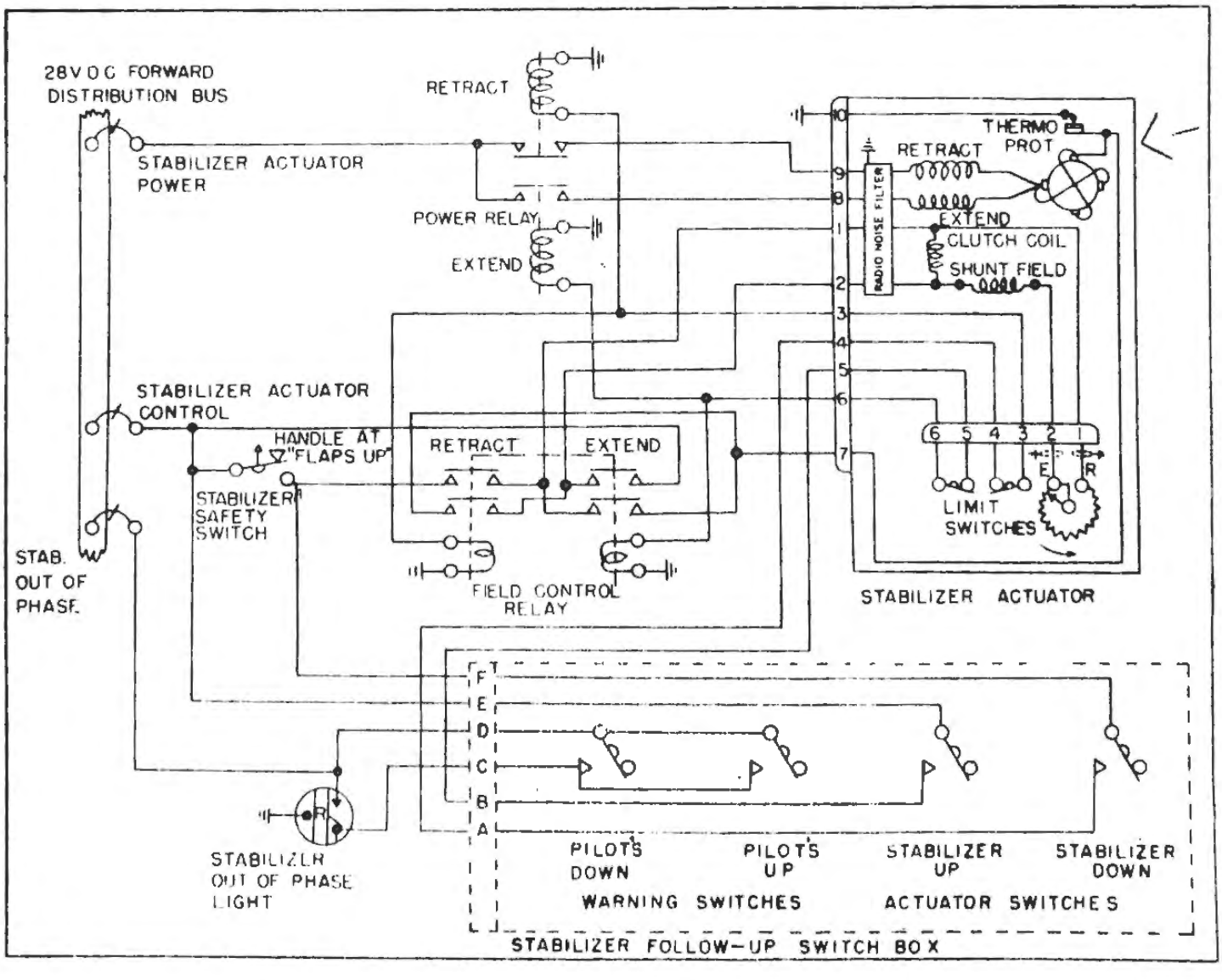


Figure 15. Variable Stabilizer Electrical System

Variable Stabilizer Electrical System Operation (Cont.).

thermo protector; thereby completing one-half of the operating circuit. At the same time, with the retract power control relay closed, a circuit will be completed to the stabilizer actuator energizing the retract series field winding of the motor through the thermo protector, completing the other half of the operating circuit. When the proper stabilizer position in relation to the flaps pre-selected position is reached, the stabilizer actuating switch in the control box will open and de-energize the retract field control relay and retract power control relay.

The thermo protector will de-energize the series field windings, shunt field windings, and the brake clutch coil should an overload or fault occur in the stabilizer actuator.

The operation of the stabilizer actuator in relation to the flap movement in the "up" direction is controlled in the same manner as it was in relation to flap down movement, except that the extend field control relay, extend power control relay and the stabilizer actuating "up" switch are used in the "extend" operation.

Out-Of-Phase Warning Light (See figure 15).

A red stabilizer out-of-phase warning light is located on the center instrument panel just below the wing flap position indicator and is used to warn the pilot when the stabilizer becomes one-half degree out-of-phase in relation to the wing flap position. This light is controlled by the retract and extend pilot warning switches located within the stabilizer control switch box on the stabilizer rear spar. See figure 16 for installation of switches.

A circuit is completed from the 28 volt d-c forward distribution bus through its circuit breaker to the retract and extend pilot warning switches. When the stabilizer is one-half degree out-of-phase in relation to the wing flap position, the corresponding warning switch will close and complete the circuit to the warning light.

Variable Stabilizer Actuator - General (See figure 23).

The variable stabilizer actuator is a linear type actuator driven by a 26 volt d-c motor and is mounted in the aft end of the fuselage at approximately station 940. It is accessible through the tail access hatch, and from the top of the fuselage by removing the fuselage hat section access panel over the stabilizer rear spar. The screw jack of the actuator is attached to a fitting on the stabilizer rear spar by means of an adjustable end fitting. The unit incorporates a motor, clutch, and brake, a variable resistance integrally mounted to control the actuator speed throughout the normal operating stroke, emergency limit switches, positive emergency stops, anti-rotational means to restrict torque loads external to the actuator, and a radio noise filter at the end of the motor to prevent excessive radio noise.

Variable Stabilizer Actuator Operation. (See figure 23).

The actuator is put into operation whenever the wing flaps are operated up or down. Control cables connected to the flap interconnector torque tube actuate the stabilizer control switch box. The normal operating stroke is controlled by means of the switches located within the stabilizer control switch box. Overtravel, which is controlled by the internal limit switches, is provided in the screw to permit the screw to travel 1/8 inch beyond the normal stroke at the retracted end, and 1/4 inch at the extended end, in the event of limit switch failure. The extreme limits of travel are fixed by non-jamming structural stops. A ring spring assembly on the screw, which is effective only on the extended end position, acts to absorb the loads due to abruptly stopping the screw. The retracted end stop consists of a spacer and nut located inside the flexible dust cover on the movable end of the screw. Motor inertia is partially eliminated by an overload clutch which restricts the amount of torque possible under stopping conditions, but will transmit adequate torque to drive the maximum required operating loads. The motor clutch and brake assembly also serves to provide quick stopping of the actuator by disconnecting the armature at the instant of applying the brake. The amount of coast is thereby held within .040 inch maximum travel. The unit is designed with limited thermal capacity and will withstand a maximum slipping duration of 7 seconds. Slipping for 7 seconds or less will not result in damage or malfuctioning of the unit. However, slipping for greater than 7 seconds will result in a defective clutch with unpredictable slip characteristics.

Emergency limit switches are built into the actuator and are adjusted to shut off the control relays before the end stops have been engaged. This prevents damage to the clutch and associated parts due to excessive clutch slippage, should the actuator run into its stops.

Inherent irreversibility in the design of the screw will prevent the actuator from changing position when subjected to the maximum static load with the brake not effective. The screw is prevented from rotating more than a few thousandths of an inch by an anti-rotational plate splined to the screw and guided by a mating spline inside the guide tube. The device is designed to withstand the operating torque loads of the actuator and prevent these loads from being transmitted to the airplane structure. A special tapered speed characteristic is provided by the variable resistance to give a lower speed at the retracted end of the stroke than at the extended end, to permit better control of the stabilizing surfaces.

The stabilizer actuator operates at certain applied loads and provides a duty cycle of one complete cycle every 20 minutes, as specified in Series 7-3. The thermo protector, within the actuator unit, will protect the motor due to overload or overheat.

Stabilizer Actuator Power Screw (See figure 23).

An acme type screw and nut assembly is used to provide linear travel at the actuator output. It is designed to obtain optimum performance and minimum end play while maintaining the proper helix angle for irreversibility and is supported by ball bearings retained in the actuator housing. A flexible bellows-type cover is used to prevent moisture and dirt from reaching the screw threads. The adjustable end fitting on the movable end of the screw will permit adjustment of the end position within ±.25 inch, in increments of .032 inch.

Stabilizer Actuator Motor (See figure 23).

The 26 volt d-c motor used to operate the actuator, is of sufficient size and incorporates the proper shunt and series windings design to provide the required speed characteristics. It is designed to operate at the required loads and to provide a duty cycle of one complete cycle every 20 minutes. The unit will start under a load of 3000 pounds. A thermal protector mounted on the motor is designed to prevent motor burn-out, should too rapid cycling be attempted for a given load. A special controlled variable-speed characteristic is obtained with the motor by operating the unit on the flat section of the magnetization curve, and reducing the field strength by a variable resistor geared to the screw travel. This gives a near linear relationship between the motor speed and the screw position at a given load. The motor may be removed from the actuator as a complete separate unit.

Stabilizer Control Switch Box (See figure 16)

The stabilizer control switch box is mounted on the aft side of the horizontal stabilizer, and is accessible by removing the fuselage hat section access panel over the stabilizer rear spar and under the rudder. It consists of four micro switches, electrical wiring, actuating arms and springs, and a control arm on the forward side of the box which is connected by a common shaft to the actuating arms. Five rigging pin holes are drilled in the mounting plate of the box and are used to rig and check settings of the switches. Two of the micro switches are used to control the "up" and "down" operation of the stabilizer actuator, while the remaining two switches energize a warning light on the pilots' instrument panel when the stabilizer is one-half degree out-of-phase with the wing flaps. When the control arm is displaced a pre-determined distance on either side of neutral by the stabilizer control quadrant, the actuating arm within the box will close the corresponding "up" or "down" switch and energize its respective side of the stabilizer actuator motor. Should the motor fail to operate, another actuating arm will close the corresponding warning switch and energize the pilot warning light after the control arm has been displaced a pre-determined distance from neutral greater than that required to actuate the stabilizer switch.

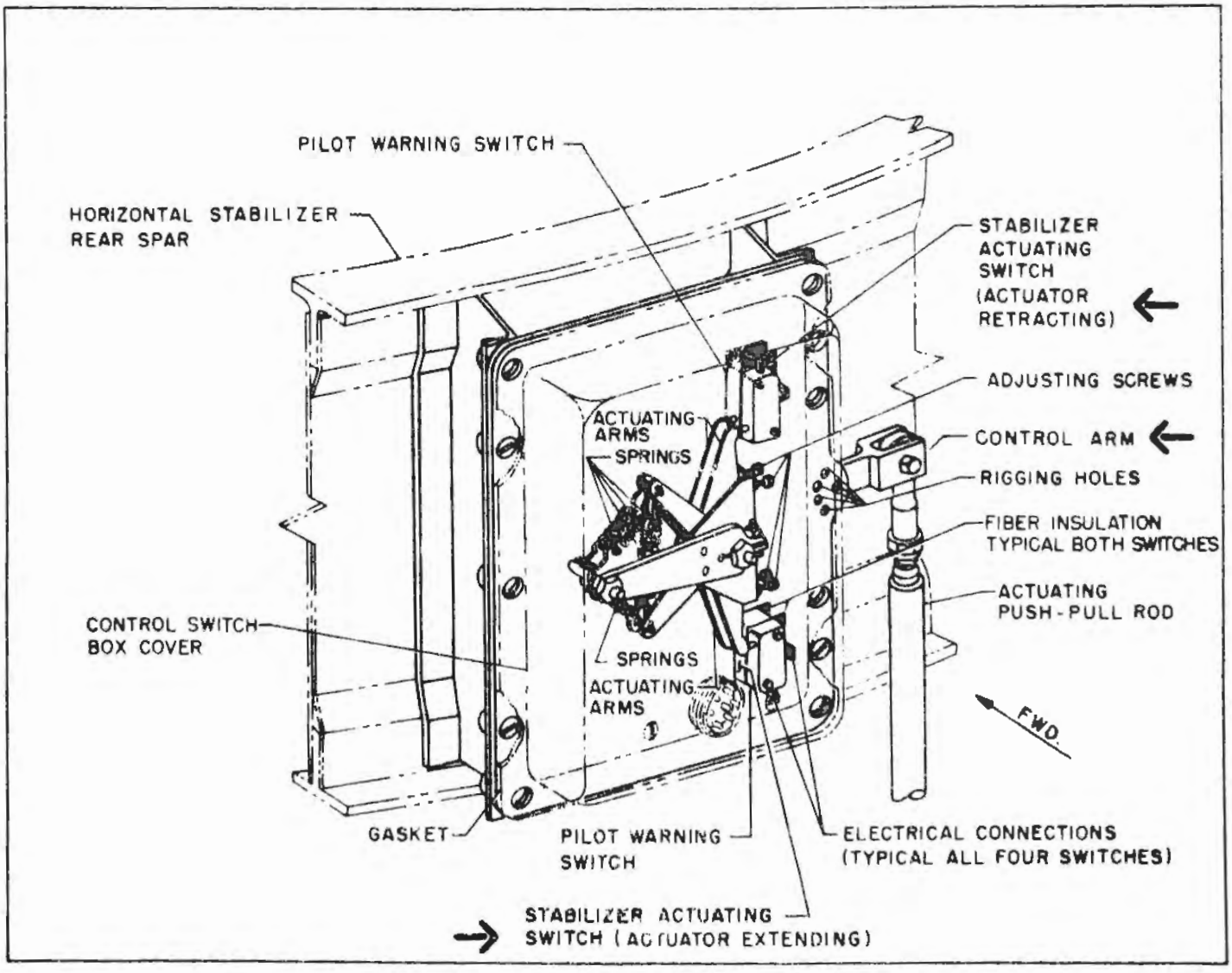


Figure 16. Stabilizer Control Switch Box

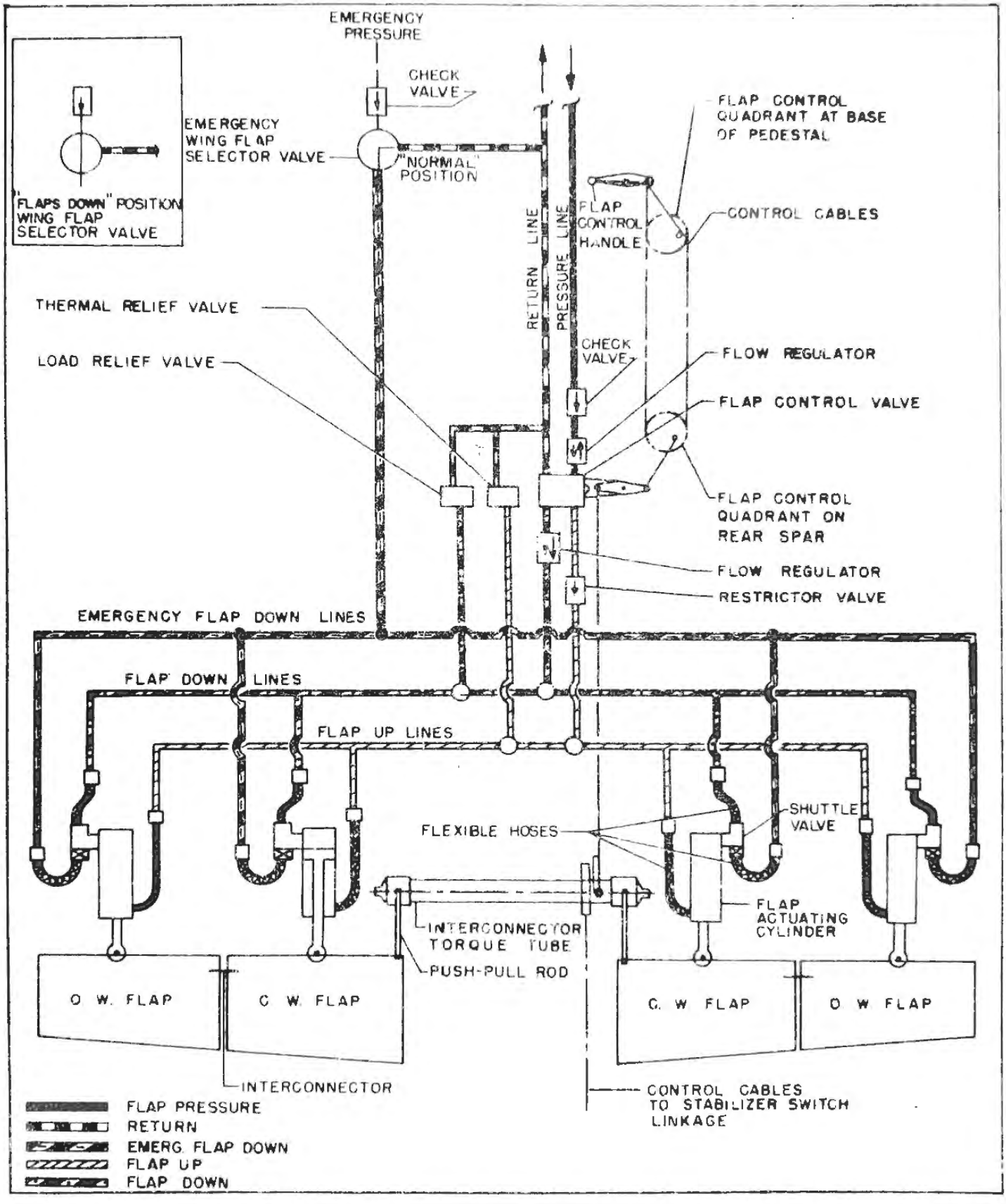


Figure 19. Flap Hydraulic Schematic

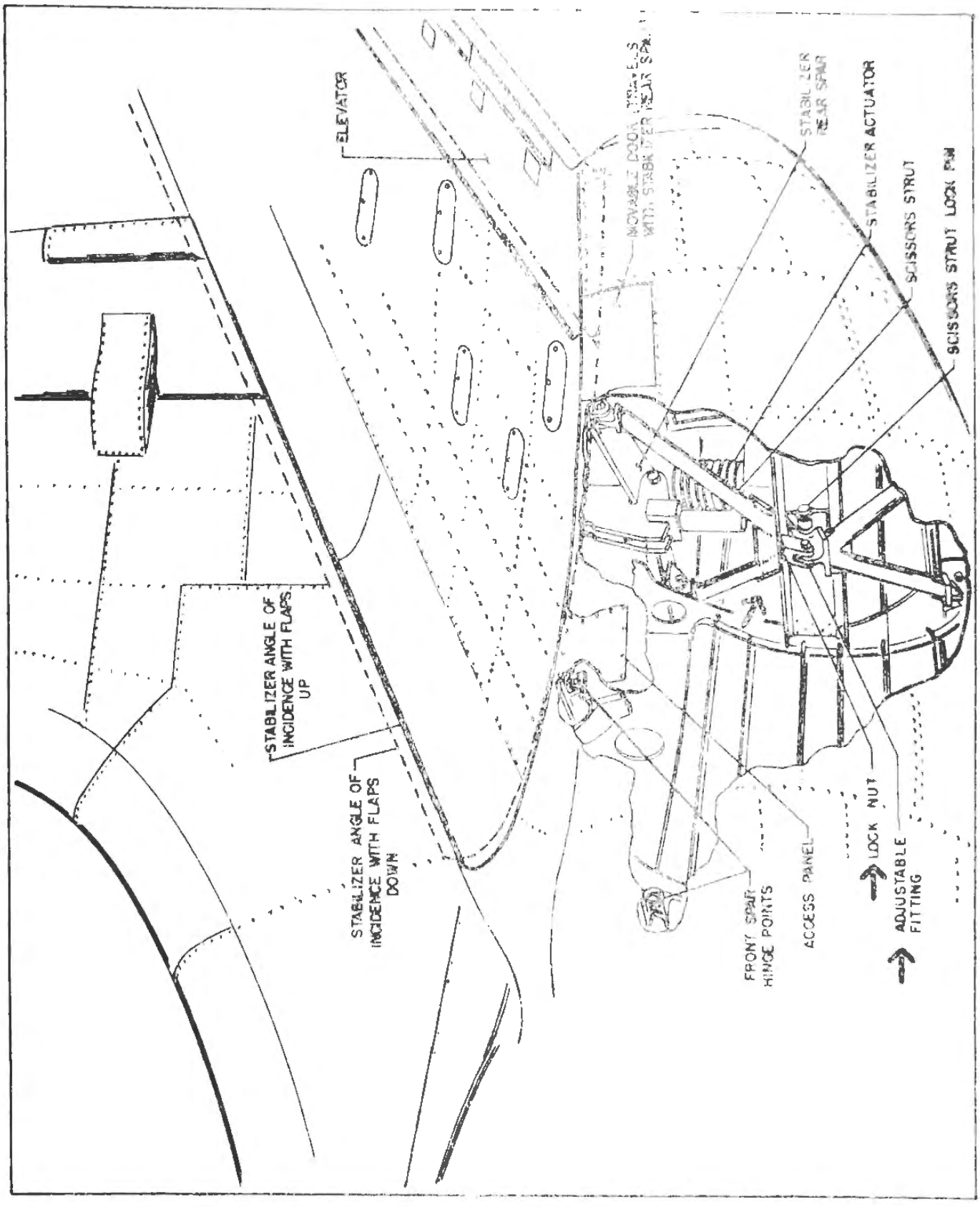


Figure 21. Stabilizer Controls Installation

Wing Flaps and Variable Stabilizer Settings

Control Handle	Flap Angle	Stabilizer Angle Of Incidence
"UP"	0°	1.40°
"TAKE-OFF"	12.5° ± 1/2°	2.4° ± .1°
"APPROACH"	24 ± 1/2°	3.05° ± .1°
"LANDING"	45 ± 1°	3.52 ± .1°
"FLAPS DOWN" (Emergency)	45 ± 1°	

Spring Back

Control	Position	Angular	Linear
"FLAPS"	"UP"	3°	3/16"
	"LANDING"	3°	3/16"
"EMERG. WING FLAPS SELECTOR"	"NORMAL"	None	None
	"FLAPS DOWN"	None	None

Rig Positions

"FLAPS" control handle - 13/64 inch from top edge of control handle to top edge of slot in pedestal.

Flap control quadrant on rear spar - Stop arm on quadrant 1/8 inch from "up" stop bolt on quadrant.

Flap Control Valve - Neutral
Wing Flaps - Flaps at 0°
Wing Flaps Slats - Flaps at 15°
Wing Flap Shutter Doors - Flaps at 0°
Stabilizer Actuator - Flaps at 0°, stabilizer at 1.4° positive incidence.
Stabilizer Control Switch Box - Control Arm Neutral (Rigging hole aligned).

Cable Tension

Refer to Series No. 22-2 - Cable Tension Chart.

Flap Position Transmitter And Indicator

Transmitter set with flaps at 24° ("APPROACH" position). Indicator to be at "APPROACH" with flaps at 24°.

Mismatch Between Flaps

Mismatch between center wing flaps - 1/8 inch maximum, as measured from top of trailing edge, with flaps at 0°.

Mismatch between outer wing flaps - 1/8 inch maximum, as measured from top of contour board to trailing edge of flap, with flaps at 0°.

Flap Extension And Retraction Time

Extention - (0° to 45°) 16 to 18 seconds
Retraction - (45° to 0°) 16 to 18 seconds

Wing Flap Actuating Cylinder

Retracted Length - 14-3/16" ± 1/32"

Rod end adjustment - 3/16" shorter 1/4" longer

Fully extended - 20-29/32" ± 1/32"

Stroke - 6.219" ± 1/2" over-travel.

Thermal Relief Valve

Cracking Pressure 1725 psi minimum
Reseat Pressure 1550 psi minimum

Wing Flap Vented Load Relief Valve

Valve adjusted to flow 1 1/2 ± 0 gpm with 915 ± 0 psi pressure at inlet port. Cracking pressure 870 psi minimum, reseat pressure 830 psi minimum. (Valves must be adjusted with a bench set-up, and not in the airplane). With wing flaps in full down (45°) position the above adjustment will permit wing flaps to begin retracting at 104 knots with increasing air speed.

Flow Regulators

Controlled at 1.3 gpm flow.

Stabilizer Actuator

Normal Extended Length (Stabilizer faired in - 13.575"

Normal Stroke - 1.695"

Stroke between Electrical stops - 1.80" to 1.85"

Overtravel beyond normal stroke in event of limit switch failure - Retract 1/8" Extend 1/4"

Adjustable end fitting - Adjustable within ± .25" in increments of .03".

Maximum slipping duration of nut with before damage - 7 seconds

Actuator travel at instant of applying brake - .040" Max. travel

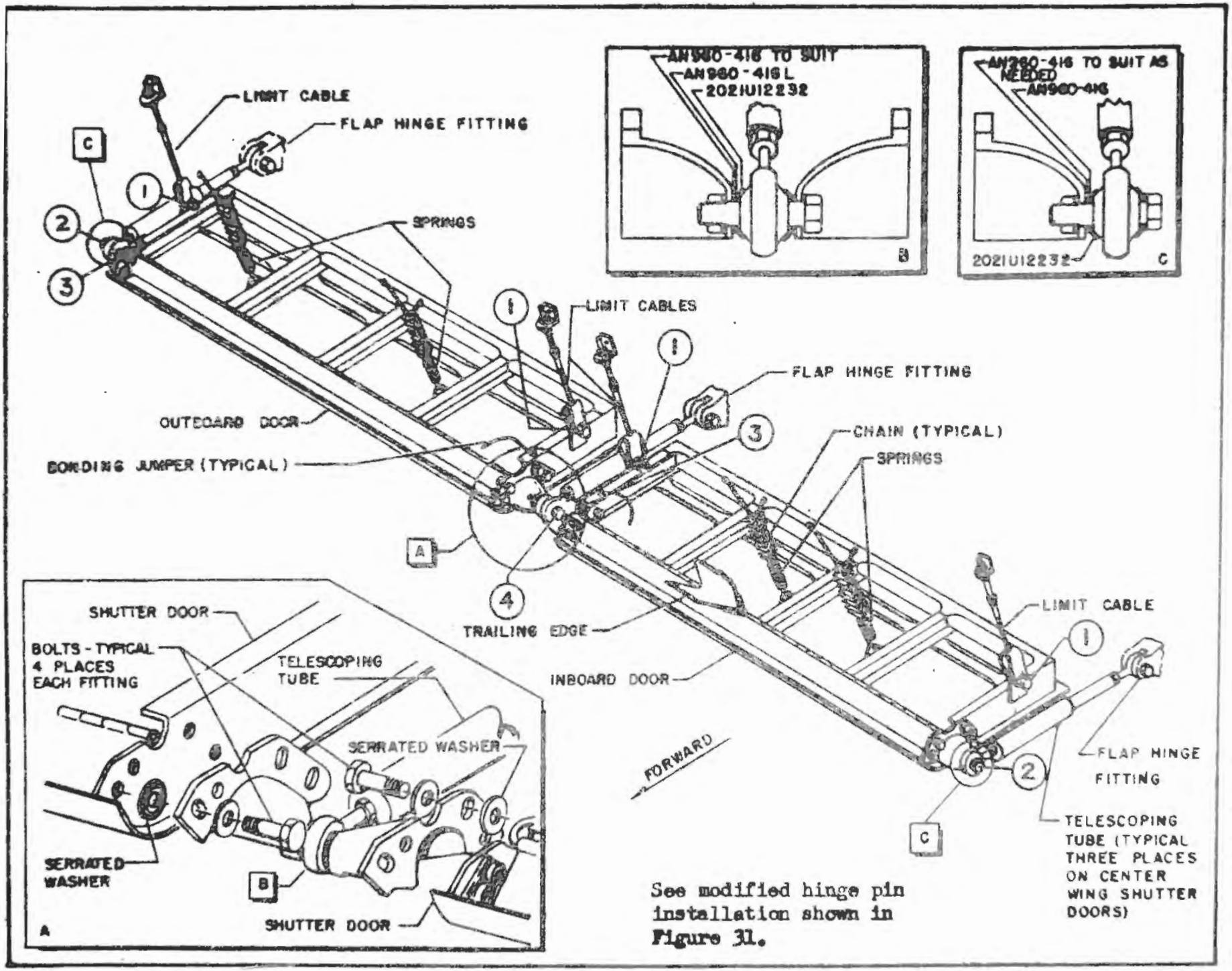
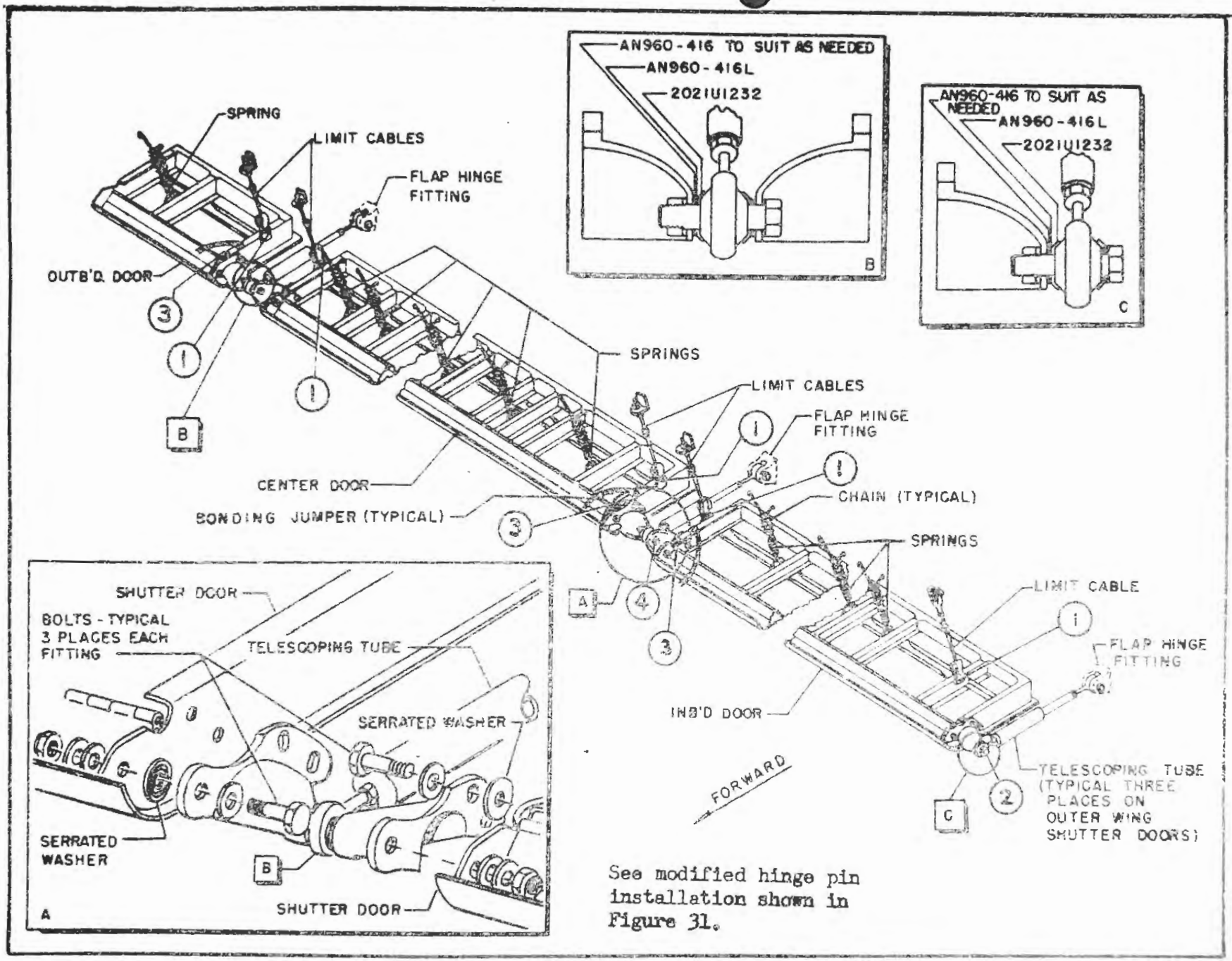


Figure 29. Center Wing Flap Shutter Door Installation



See modified hinge pin installation shown in Figure 31.

Figure 30. Outer Wing Flap Shutter Door Installation

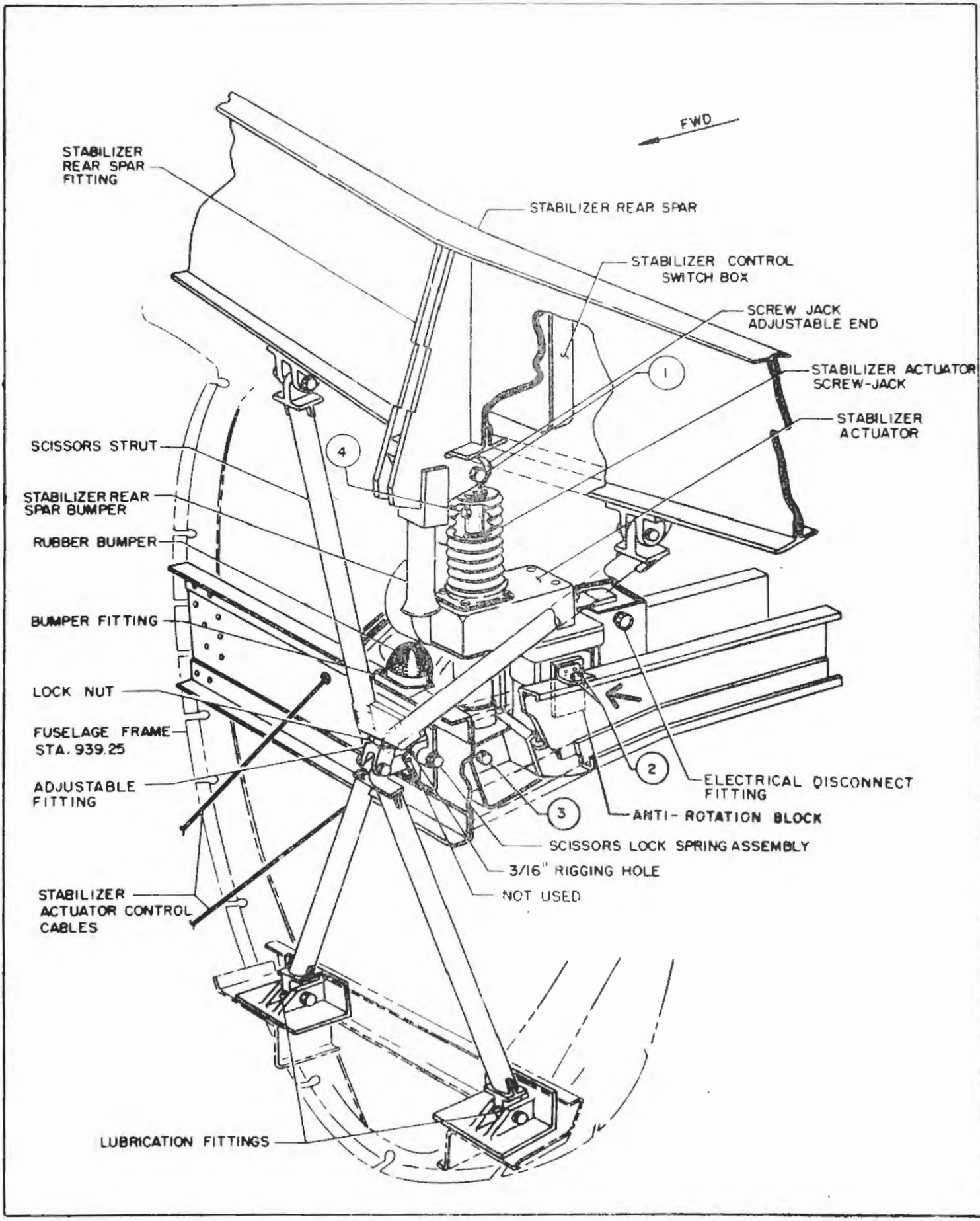
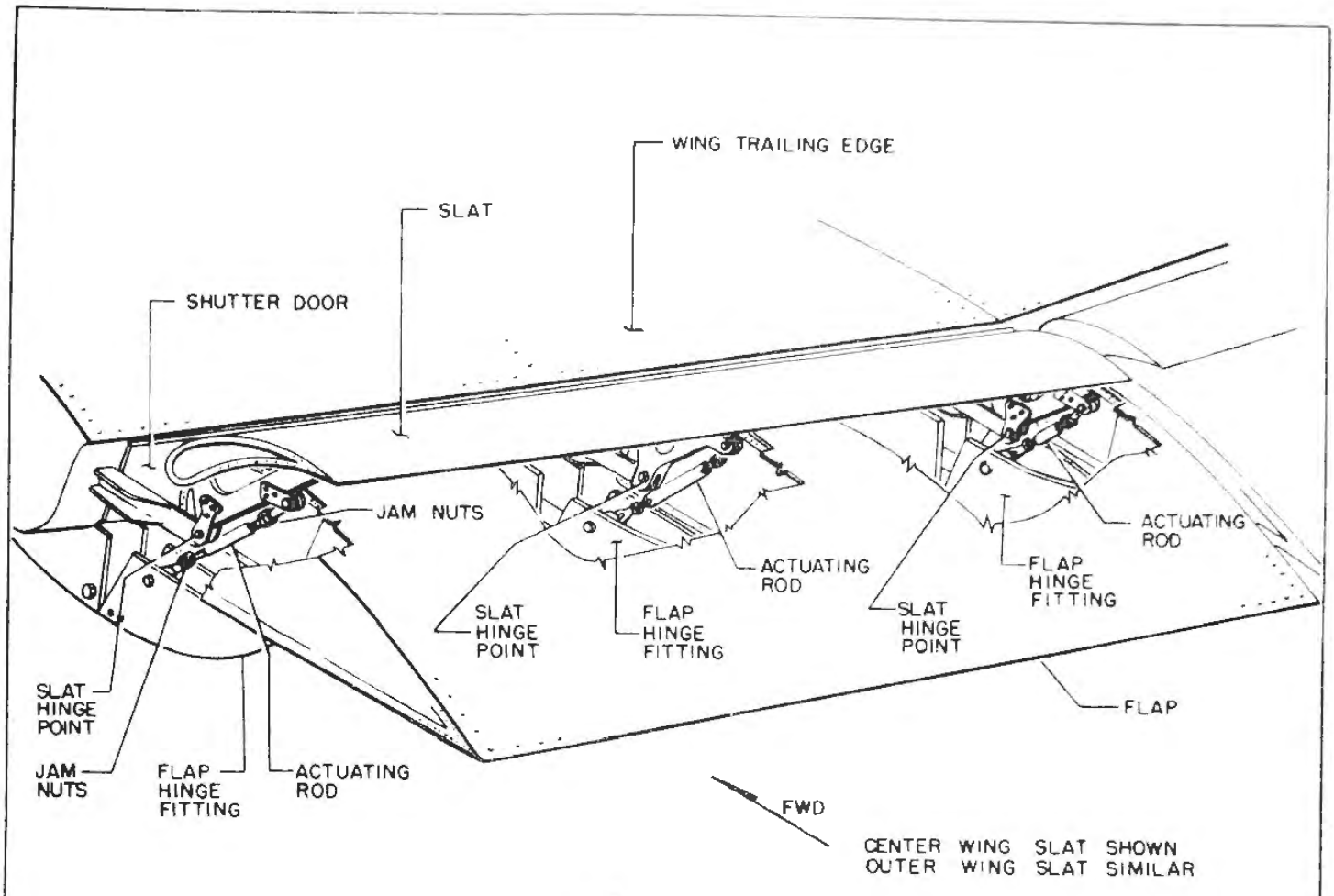
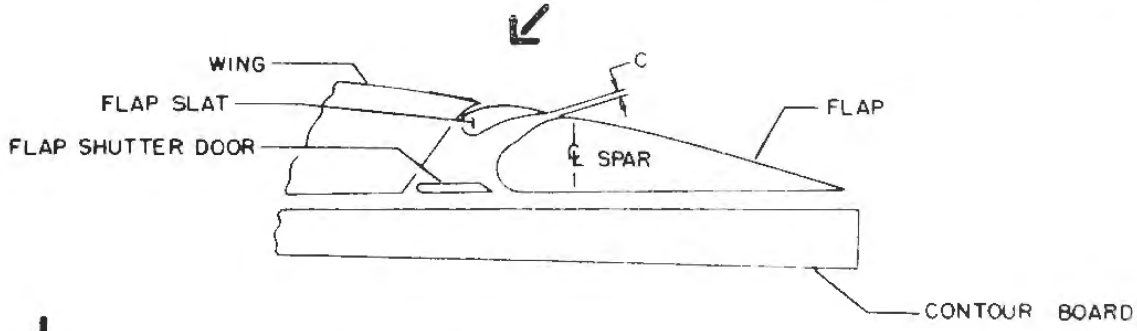


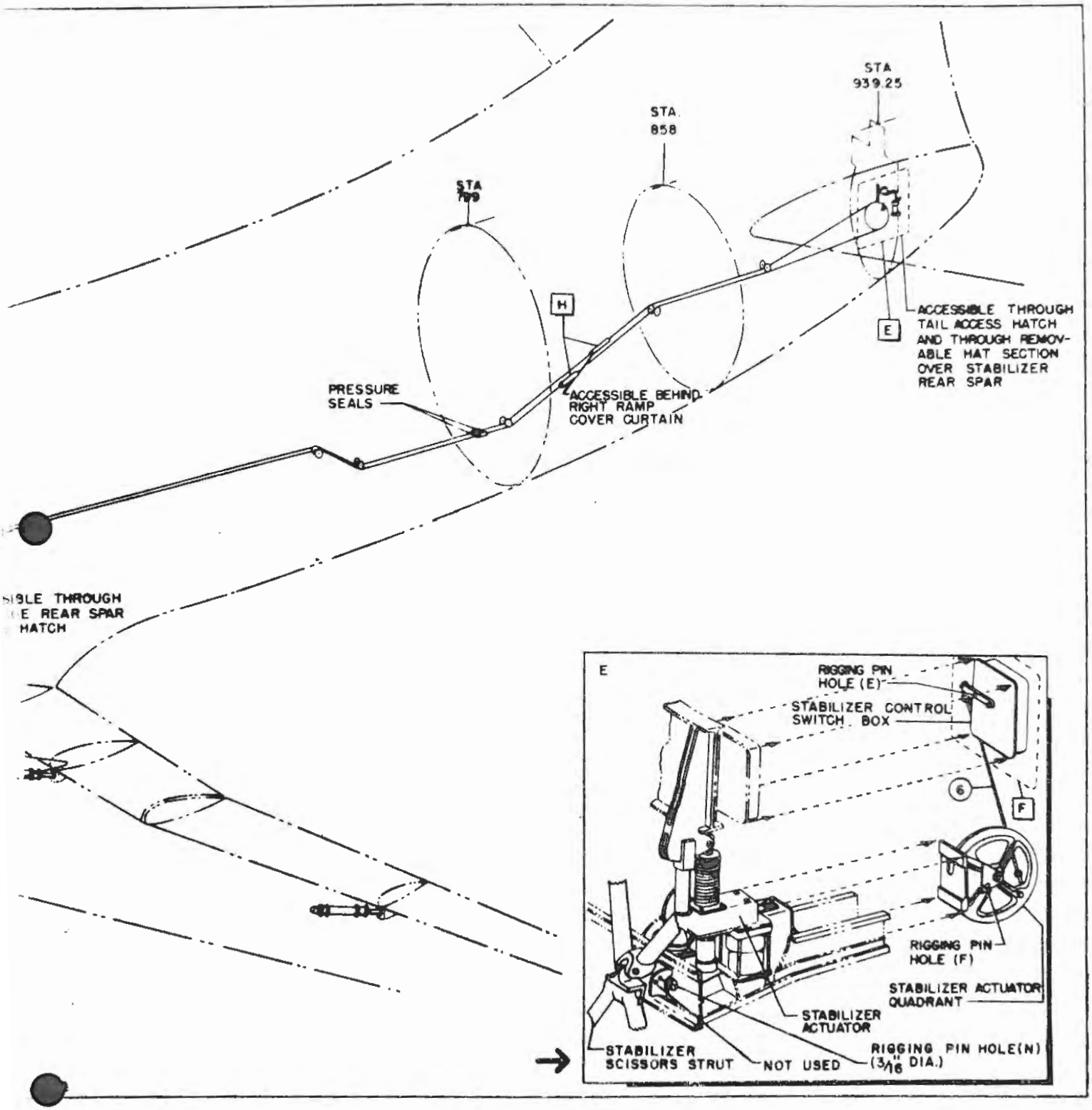
Figure 37. Stabilizer Actuator Installation





FLAPS	WING STATION	LOCATION	C
15°	71.25	CENTER WING SLAT, 16-1/2 INCHES FROM INBOARD END OF SLAT	$2\frac{1}{4}" + \frac{5}{32}"$
15°	181	CENTER WING SLAT, 3-9/16 INCHES FROM OUTBOARD END OF SLAT	$1\frac{15}{16}" + \frac{5}{32}"$
15°	198.73	OUTER WING SLAT, 21-5/8 INCHES FROM INBOARD END OF SLAT	$1\frac{29}{32}" + \frac{5}{32}"$
15°	393.5	OUTER WING SLAT, 8-3/4 INCHES FROM OUTBOARD END OF SLAT	$1\frac{7}{16}" + \frac{5}{32}"$
0°	55	CENTER WING SLAT, INBOARD END OF SLAT.	$\frac{35}{64}" + 1/32"$ $- 1/16"$
0°	405	OUTER WING SLAT, OUTBOARD END OF SLAT	$\frac{1}{4}" + 1/32"$ $- 1/16"$

Figure 39. Flap Slat Rigging Diagram



Variable Stabilizer Rigging

SURFACE CONTROLS - GENERAL (See figure 17).

This airplane is controlled by conventional aileron, rudder and elevator control surfaces. These control surfaces are operated by a dual set of controls in the pilots' compartment, each consisting of a control column and wheel, and rudder pedals. These pilot compartment controls operate the control surfaces through levers, torque tubes, flexible preformed steel cables, and push rods.

The aileron and elevator surfaces are equipped with trim tabs which are operated by controls on the pedestal. The rudder surface is equipped with a combination trim and spring tab. The trim action of the tab is controlled by a control on the pedestal, while the spring action is controlled by forces in the rudder system. The elevators, in addition to the trim tabs, also have separate spring tabs which are operated by forces in the elevator system. The trim tab controls on the pedestal, which are accessible to both the pilot and co-pilot, operate the tab surfaces through chains and sprockets, torque tubes, flexible preformed steel cables, tab actuators (screws jacks) and push rods. All trim tab controls are the non-creeping type (see figure 27).

A gust lock control system is provided to lock the main control surfaces in neutral and prevent them from being moved by gusty or windy weather conditions (see figure 31).

Rigging pin holes are provided in the various components and the adjacent structure of all control systems. Rigging pins are inserted in these holes to hold the components in neutral while the cables are being rigged. All cables in all control systems are equipped with pressure seals at points where cables run through the pressurized boundry area of the fuselage.

Rigging Pins.

Rigging pins are used in all the main control systems, trim tab systems and in the gust lock control system to position and hold the various bellcranks, levers, torque tubes, and cable drums in a rig position while the connecting cables, chains or pushrods are being adjusted. These pins may be either AN bolts or steel rods of sufficient length and diameter. Rigging pin holes, to accommodate these pins, are provided in the various bell cranks, levers, torque tubes, and drums and vary in size from 3/16 inch to 3/8 inch. The proper size pin must be used in a rigging hole. For example, a 3/16 inch pin must not be used in a $\frac{1}{4}$ inch hole. Sufficient clearance (approximately .010 inch) is provided in the holes to permit easy insertion or removal of the pins when the system is adjusted correctly.

Rigging pins, in addition to being used in the adjustment of the control systems, are also used in determining that the systems are adjusted correctly. If rigging pins are easily inserted and removed with the fingers when a control system is positioned in the rig position, then that system is properly rigged.

WARNING

All rigging pins must be removed from a control system before operating it. All rigging pins must be removed from all control systems before releasing the airplane for flight.

Control Cables And Pressure Seals.

The control cables used in the main flight control systems, trim tab control systems and gust lock control system are flexible preformed carbon steel cables. These cables are prestretched and dipped in a hot rust prohibitive coating before installation. Swaged fittings are used on the ends the cables for attachment purposes. Sufficient pulleys and/or fairleads are provided on cable runs to adequately dampen out excessive cable vibration. Cables must not rub pulley flanges at take-off points. Cables may rub on a few fairleads but not an excessive number. Not more than 3/4 pound should be required to pull a cable free of a fairlead unless the fairlead is near a turnbuckle, then a maximum load of $1\frac{1}{2}$ pounds is permissable.

All control cables in the fuselage that extend beyond the pressurized boundry area pass through pressure seals. These seals, which are replaceable, are attached to the airplane structure and are used to prevent the leakage of cabin pressure past the cable openings. Both control cables and pressure seals are lubricated at regular intervals to prevent excessive control system friction and wear at the seals. Refer to Chapter 14 for further information on lubrication of control cables and pressure seals.

Temperature Correction Of Cable Rigging Loads.

Change in cable rigging load is caused by a relative change in length between the control cable and the airplane structure when the temperature changes. Because there may be a large temperature change when an airplane is rigged in a hangar and then moved outdoors, it is necessary to correct the required rigging load for the existing outdoor temperature condition at the time of rigging. Refer to Chapter 22 for further information on temperature correction of cable rigging loads and correction chart.

Contour Boards.

Contour boards are used to locate the aileron, rudder and elevator control surfaces in a faired-in (neutral) position with relation to the main surfaces to which they are attached. These contour boards are long aluminum channels which extend from the front spar of the main surfaces to a point slightly aft of the trailing edge of the control surfaces. Attached to the contour boards are locating blocks which locate the contour boards at their proper stations.

Contour Boards (Cont.).

The locating blocks on the aileron contour board each have two 1/8 inch pins so that the board may be used for the right or left aileron. These pins are inserted in the locating holes in the outer wing, one in the front spar and one in the rear spar, just outboard of the landing light at wing station 472.

The locating blocks on the elevator and rudder contour boards each have 3/16 locating holes which match the locating holes on their respective main surfaces. The vertical fin and horizontal stabilizer locating holes are equipped with anchor nuts so that the contour boards may be bolted through the locating blocks to their respective main surfaces. The locating holes in the side of vertical fin, one at front spar and one at the rear spar, are at fin station 6.0. The locating holes in the top horizontal stabilizer are in the front and rear spars on each side at stabilizer station 19.6. Flush screws are installed in these locating holes in the vertical fin and horizontal stabilizer at all times except when contour boards are installed.

The aft ends of all the contour boards are designed so that the trailing edges of the control surfaces are one inch from the boards when the control surfaces are in neutral. Fair-in (neutral) tolerances are given in Series 3 of this chapter for variations from this one inch neutral setting.

Tool numbers for the contour boards are listed in the respective control adjustment procedure.

Control Movement Gages.

Movement gages are used to check the throws of all three main control surfaces and their tabs. The movement gages give an angular reading in degrees. The throws may also be checked by linear movement, if gages are not available. The linear movement of the aileron and aileron tab is checked at their outboard trailing edges. The linear movement of the rudder and rudder tab is checked at the bottom trailing edge of each. The elevator linear throw is checked at the inboard trailing edge and the elevator trim tab and spring tab are checked at their respective outboard trailing edges.

The various control adjustment procedure list the movement gages and show them installed on the control surfaces.

RUDDER AND RUDDER SPRING TAB CONTROL SYSTEM - GENERAL (See figure 17).

A single rudder is used to provide directional control of the airplane, and is controlled by a dual set of rudder pedals in the pilot's compartment The rudder pedals are connected by push rods and a torque tube to cable horns beneath the pilots' compartment floor. Single 3/16 inch 7 X 19 flexible preformed carbon steel cables running down each side of the fuselage extend from these cable horns aft to a quadrant mounted on bearings on the rudder torque tube. The quadrant is connected to the rudder by means of a preloaded spring cartridge. A mechanical spring tab linkage is so arranged that differential motion between the quadrant and rudder, resulting from spring compression, is transmitted through the linkage to operate a combination spring and trim tab. Attached to the rudder torque tube section of the quadrant and to the fuselage structure is a rudder reversal spring cartridge which insures a positive return action on the rudder controls in critical flight conditions.

Three sets of turnbuckles are used in the rudder system cables The forward and center sets of turnbuckles are located in the belly of the fuselage and are accessible through the forward heater hatch and the electrical hatch respectively. The aft set of turnbuckles are located in the ramp area and are accessible behind the right and left ramp curtains.

RUDDER AND RUDDER SPRING TAB SYSTEM OPERATION. (See figure 17).

The rudder control system is operated by the forward and aft movement of either of the dual set of rudder pedals in the pilots' compartment. Each rudder pedal is connected to a "Y" shaped bracket which is mounted free floating on a shaft below the floor The lower horn of each "Y" shaped bracket is attached by a push rod to an arm on the torque tube forward of and parallel to the shaft upon which then"Y" shaped brackets are mounted. Thus, a pushing movement on the right pedal will cause the rotation of the attached "Y" shaped bracket, which in turn will rotate the torque tube. The rotation of the torque tube will exert a pushing force on the push rod connected to the other "Y" shaped bracket, resulting in a reverse movement of the left pedal. A reverse movement of the right pedal will occur when the left pedal is pushed.

Rudder pedal forces are transmitted to the lower section of the rudder quadrant, mounted in the aft end of the fuselage under the rudder, by single cables which connect the quadrant to horns on the rudder pedal torque tube. The lower section of the rudder quadrant drives the upper section through the spring cartridge. The upper section of the quadrant is bolted to the bottom of the rudder. Normally the lower section drives the upper section directly with no relative movement between the driving section (lower) and the driven section (upper) but when control loads exceed an amount predetermined by the strength of the spring cartridge, the spring deflects and the driven section lags on the driver section.

This relative motion is picked up by the spring tab linkage attached to the driver section. The linkage actuates a bellcrank assembly, the pivot point of which is fixed to the driven section. Thus, any relative motion between the lower and upper sections of the rudder quadrant is converted to motion on the push-pull rod which is connected to the bellcrank assembly. Movement of this push-pull rod actuates the lever assembly attached to the yoke on the rudder tab actuator (screw jack), deflecting the combination trim and spring tab in the opposite direction the rudder is moved by the upper (driven) section of the quadrant.

A rudder reversal spring cartridge is attached to the forward mounting bolt of the rudder spring cartridge on the upper section of the rudder quadrant and to the fuselage structure. This reversal spring cartridge comes into play and tends to return the rudder to neutral when the rudder is deflected 12 degrees on either side of neutral. See figure 21 for a detail of the rudder spring tab system.

Rudder (See figure 1).

The rudder consists of an aluminum alloy spar, rib assembly and reinforced leading edge, and is covered with fabric. It is attached to the vertical fin with anti-friction bearings at the three hinge points. The rudder is statically balanced to within 100 to 118 inch pounds tail heavy. Balance weights are attached to the leading edge above the top hinge and are readily accessible through a removable cover for changing the mass balance. A fitting, located on the bottom of the rudder at the leading edge, strikes against adjustable stops on the fuselage closing rib, thus limiting the amount of rudder travel on each side of neutral. A lock fitting, also installed on the bottom on the rudder aft of the hinge line, is used in conjunction with the gust lock control system to lock the rudder in neutral. An all metal combination trim and spring tab is hinged to the aft end of the rudder. Access plates are provided in the rudder surface for accessibility to the trim and spring tab control rods, rudder torque tube attaching bolts and to the upper tab hinge pin. A removable section of the trailing edge below the tab provides access to the lower tab hinge pin. A static discharger is located on the trailing edge to dissipate static electricity. The rudder is interchangeable between airplanes.

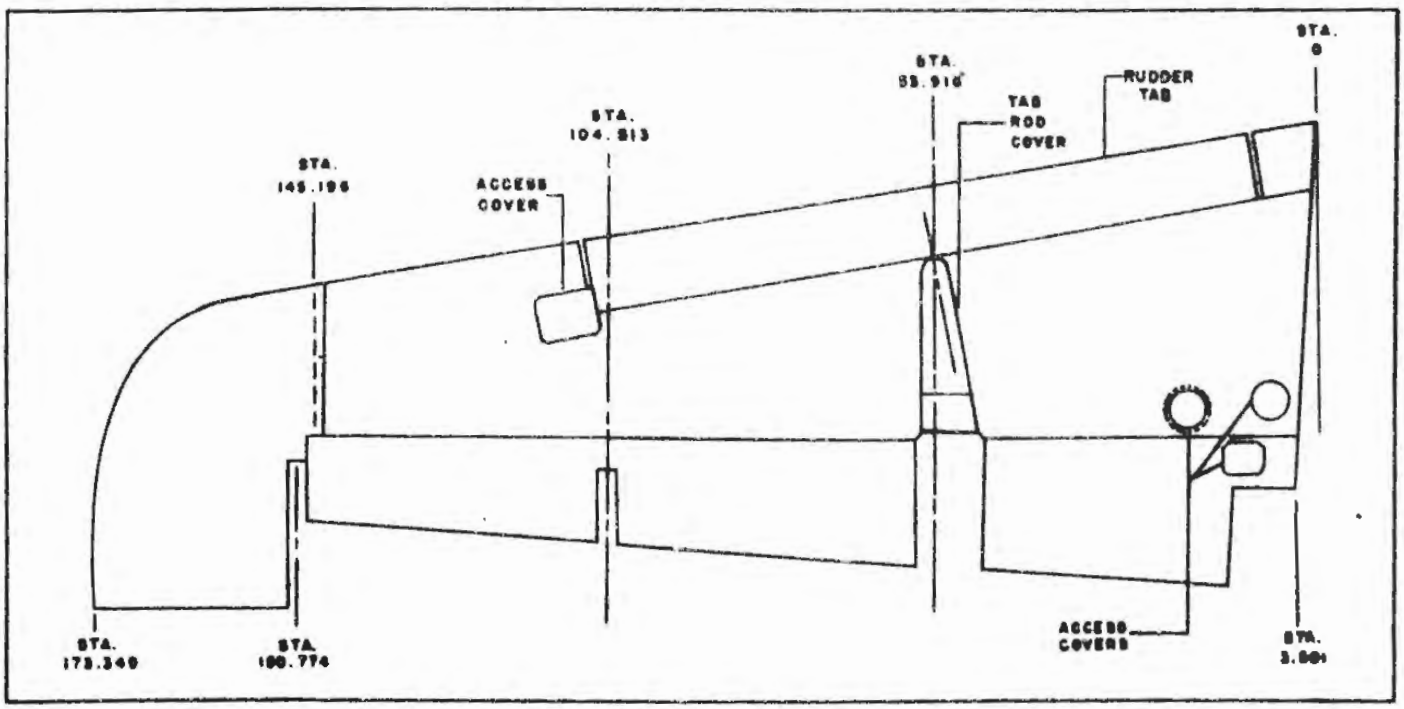


Figure 1. Rudder Station Diagram

Rudder Pedals (See figure 2).

A dual set of combination rudder and brake pedals are provided in the pilots' compartment, one set for the pilot and one for the co-pilot. These pedals are attached to free floating "Y" shaped brackets extending above the floor and pivoting on a shaft just below the floor. These brackets are connected to a torque tube forward and parallel to the "Y" brackets' shaft by push rods. Attached to the upper ends of the "Y" brackets is a rack with six notches. The rudder pedals are adjustable in any one of these six notches to adapt the control system to individual pilots. Movement of the position of the pedals in relation to the "Y" bracket is made by moving a lever adjacent to the pedal to disengage the pedal adjusting linkage from the notch in the rack, at the same time moving the pedal to the desired position and then engaging the adjusting linkage in rack notch. For rigging purposes, the rudder pedals are considered to be in neutral when the pedal adjusting linkage is engaged in the third notch from the forward end of the rack. A 1/4 inch rigging pin hole is provided in the aft leg of each "Y" bracket to lock the pedals in neutral while adjusting or checking the rudder system rigging. In order to keep debris out of the mechanism, protective covers are provided around the pedal shafts and are fastened to the floor by Airloc fasteners. Refer to Chapter 15 for information on the brake section of the pedals.

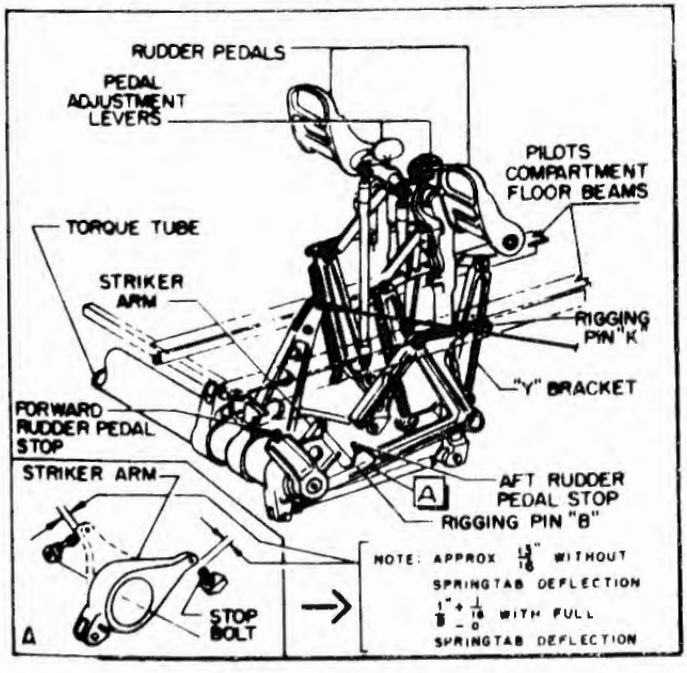


Figure 2. Rudder Pedals And Torque Tube

Rudder Quadrant (See figure 3).

The rudder quadrant is mounted on the lower vertical fin hinge bracket in the aft end of the fuselage. The quadrant is in two sections, an upper and a lower section. The lower section of the quadrant is mounted on bearings on the upper section. Control cables from the rudder pedal torque tube are connected to the sides of the lower section of the quadrant, while the torque tube of the upper section is bolted directly to the bottom of the rudder. A rudder spring cartridge is used to connect the upper and lower sections. Thus, when the rudder control cables are moved the lower section of the quadrant will drive the upper section through the spring cartridge and deflect the rudder. Connected to the lower or driver section of the quadrant is the spring tab linkage which actuates a bellcrank pivoted on the upper or driven section of the quadrant when the spring cartridge is deflected by control loads that exceed the preload strength of the spring cartridge. Also connected to the upper section of the quadrant at the point where the spring cartridge attaches to the upper section, is the rudder reversal spring cartridge. The forward end of this reversal spring cartridge is attached to the fuselage structure.

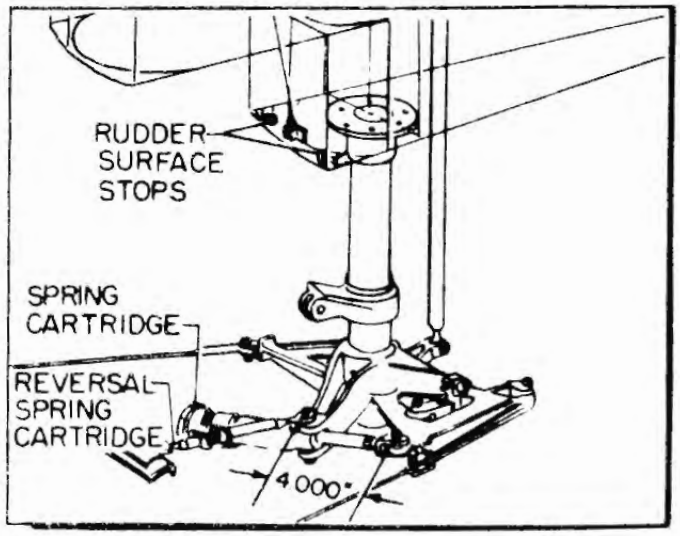


Figure 3. Rudder Quadrant

Rudder Spring Cartridge (See figure 4).

A rudder spring cartridge is installed on the rudder quadrant to connect the lower section of the quadrant to the upper section. Normally this spring will not be deflected during movement of the rudder controls; but when control loads exceed an amount predetermined by the spring preload, the spring will deflect and the upper section of the quadrant will lag on the lower section. This lag will be picked up by the spring tab linkage, thus deflecting the spring tab and adding assist to the rudder controls.

Rudder Spring Cartridge (Cont.).

The rudder spring cartridge consists of a housing with an internal compression spring, a shaft extending out both ends of the cartridge housing with a clevis fitting on the aft end, and adjustment and lock nuts. The internal spring is preloaded to 15 ± 2 pounds by adjusting the cap nut and stop nut on the forward end of the cartridge. The preload can be checked by pushing the clevis end of the shaft into the cartridge. Limit travel of the spring is adjusted by a nut on the forward end of the shaft and by two jamb nuts on the clevis end. The adjusting nut on the forward end of the shaft is locked in place by a cotter pin. The preloading of this cartridge will not normally require adjustment; but should preload require adjustment, replace spring cartridge with a serviceable unit.

Rudder Reversal Spring Cartridge (See figure 5.

A rudder reversal spring cartridge is installed at the rudder quadrant in the aft end of the fuselage to insure a positive return action on the rudder controls in critical flight conditions. This reversal spring cartridge comes into play when the rudder is deflected 12 degrees on either side of neutral, thus applying a force to the rudder to return it to neutral when the opposing force is removed from the pedals. The rudder reversal spring cartridge consists of two tubes, one telescoping over the other with an external compression spring installed over the outside tube and held in place by two pins extending through slots in both tubes. The forward end that attaches to the fuselage structure is equipped with an adjustable eyebolt so that the spring cartridge can be adjusted when rigging the rudder control system.

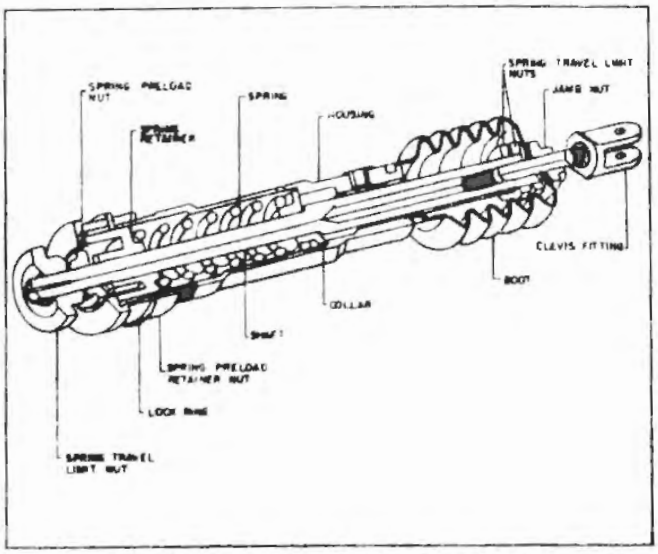


Figure 4. Rudder Spring Cartridge

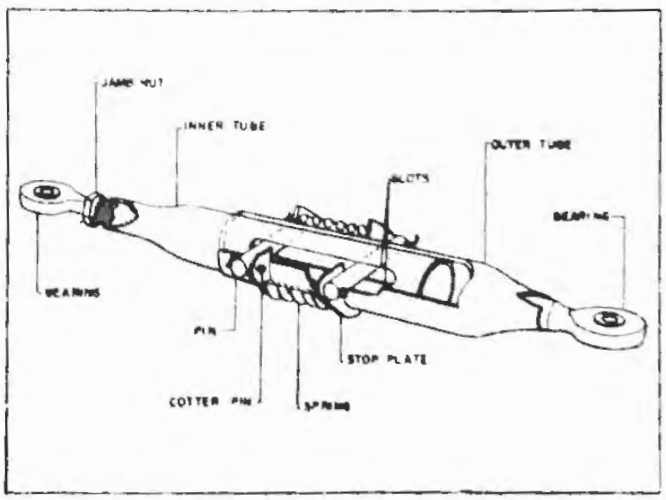


Figure 5. Rudder Reversal Spring Cartridge

RUDDER TRIM TAB SYSTEM - GENERAL. (See figure 19).

The rudder trim tab system is controlled from a knob on the pedestal which is readily accessible to both the pilot and co-pilot. The control knob is connected by a gear box, chain and torque tube shaft to a cable drum under the floor. Single 3/32 inch, 7 x 7, flexible preformed carbon steel cables running aft connect this drum under the floor with another drum in the vertical fin. This fin drum is connected by a torque to the tab actuator on the lower rudder hinge bracket. Connected to this tab actuator, at the yoke end is the spring tab system linkage and the push rod which actuates the combination trim and spring tab surface on the trailing edge of the rudder.

The turnbuckles and vernier links used in adjusting the rudder trim tab system cables are located in the belly of the fuselage below the cabin floor and are accessible through the air conditioning hatch #80. Cable disconnect fittings are located within the vertical fin and are accessible through access doors in the left side of the fin.

Rudder Trim Tab System Operation (See figure 19).

The rudder trim tab is controlled by a knob near the aft end of the pedestal. Rotation of this knob in either direction drives a gear box below the knob. Motion from the gear box is transmitted by a chain and sprockets to a torque tube shaft below the pedestal, which in turn rotates a cable drum under the right side of the pilots' compartment floor. Motion from this cable drum is transmitted aft by two cables to a similar drum located within the vertical fin. Connected to the aft end of this fin drum is a torque tube which actuates the trim tab actuator (screw jack). This actuator in turn moves the trim tab actuating push rod connected to the yoke on the aft end of the actuator, and deflects the combination spring and trim tab (see figure 27).

Rotation of the "RUDDER TAB" control knob to "NOSE LEFT" will deflect the trim tab to the right in relation to the rudder surface. Rotation of the control knob to "NOSE RIGHT" will deflect the trim tab to the left in relation to the rudder surface.

Rudder Trim Tab (See figure 1).

The rudder trim tab is of all metal construction and is attached to the lower section of the rudder trailing edge by means of a piano type hinge. The hinge pin attaching the tab to the rudder is in two sections. The upper hinge pin is secured to the rudder framework and is accessible for removal through an access opening in the left side of the rudder just above the tab. The lower hinge pin is held in place by a 90 degree bend in the bottom of the pin and is accessible for removal by removing the lower section of the rudder trailing edge. This trim tab is controlled by both the trim tab control system and the rudder spring tab system.

Rudder Trim Tab Control Mechanism. (See figure 25).

The rudder trim tab control mechanism is mounted on the top aft end of the pedestal in pilots' compartment and is accessible to both the pilot and co-pilot. This control mechanism consists of a control knob and dial, a gear box and chain sprocket, chain, torque tube shaft and chain sprocket, and a cable drum. Rotation of the control knob drives the gear box and chain sprocket. Motion from the gear box is transmitted by the chain to the torque shaft, which in turn rotates the cable wound drum at the end of the shaft. Internal stops within the gear box limit the rotation of the control knob to an indicated 20 degrees on either side of neutral.

Due to the type of construction of the rudder tab control gear box, some roughness may be encountered when rotating this unit. This roughness is due to the beveled gears within the unit meshing and should not be cause for replacement if the system is working satisfactorily. The degree of roughness and/or backlash of the gears is controlled by the use of shims between the two sections of the gear box housing and on the chain sprocket shaft. These shims should be added or removed so that backlash is limited to a maximum of .006 inch. Normally this shimming is done at the overhaul base.

Rudder Trim Tab Actuator (See figure 6).

The rudder trim tab actuator mounted on the lower rudder hinge bracket is a screw jack type mechanism. This actuator converts rotating movement of the vertical fin cable drum and connecting torque tube to "in" and "out" movement of the yoke end of the unit. The actuator consists of a housing with four mounting bolt holes, an internal screw jack assembly, a yoke fitting on the aft end of the screw jack assembly, a dust cover boot, and a lubrication fitting. Rotation of the shaft end of the actuator turns the internal screw jack assembly and moves the yoke end "in" or "out" depending on the direction of shaft rotation. Attached to the yoke end of the actuator is a lever assembly which picks up motion from the spring tab linkage and transmits it to the trim tab. Refer to Chapter 14 for information on lubrication of the tab actuator.

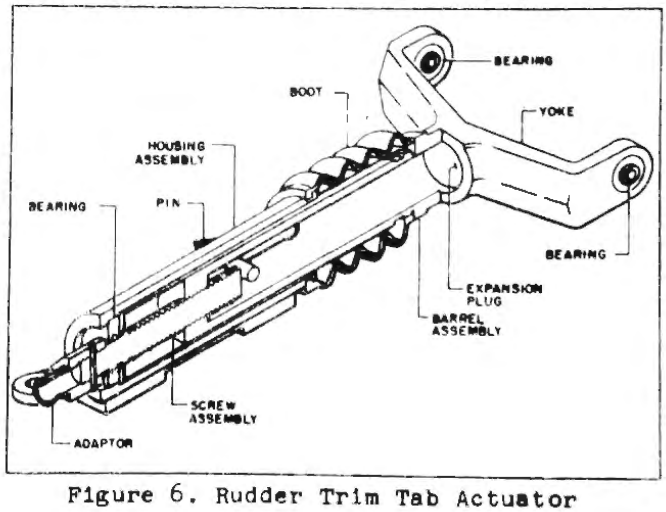


Figure 6. Rudder Trim Tab Actuator

ELEVATOR CONTROL SYSTEM - GENERAL.
(See figure 17).

Aluminum alloy covered elevator surfaces are used to provide longitudinal control of the airplane, and are controlled by the fore and aft movement of the dual control columns in the pilots' compartment. Single 3/16 inch 7 X 19 flexible preformed carbon steel cables connect a horn at the bottom of the left column with a cable mast on the elevator torque tube in the aft end of the fuselage. The cable mast is connected to the torque tube by means of a preloaded spring cartridge. Differential motion between the mast and the torque tube resulting from spring deflection is transmitted through a push-pull linkage to operate separate spring tabs, one on each elevator surface. Levers on the torque tube are connected to the elevator surfaces by push-pull rods. The elevator trim tabs provide a balance action of a 0.2 degree lag for every 1.0 degree of elevator travel.

Three sets of turnbuckles are used in the elevator system cables. The forward and center sets of turnbuckles are located in the belly of the fuselage and are accessible through the forward heater hatch and the electrical hatch respectively. The aft set of turnbuckles are located in the ramp area and are accessible behind the left side ramp curtains.

WARNING

The elevator control columns must not be permitted to free fall forward against the column stop. The elevator bungee puts a forward force into the control columns and damage may result to the structure or personnel.

ELEVATOR CONTROL SYSTEM OPERATION
(See figure 17).

The elevator control system is operated by the forward and aft movement of the dual control columns in the pilots' compartment. Each control column is an integral part of a single torque tube located below the floor. Connected to a horn on the bottom of the torque tube are the dual control cables which run aft and connect to the cable mast (spring tab arm) on the elevator torque tube.

Control column forces are transmitted to the cable mast on the elevator torque tube by the control system cables. This mast in turn imparts motion to the bellcrank assembly, which is bolted to the torque tube, through the preloaded spring unit. When loads resisting elevator movement do not exceed the preload of the spring unit, motion will be transmitted directly to the torque tube without deflection of the spring unit. Push-pull rods connect levers on the torque tube with horns on the elevator surfaces and transmit rotation of the torque tube to "up" and "down" movement of the elevator surfaces.

In the event motion is transmitted to the cable mast on the elevator torque tube by the control column when loads on the elevator surfaces are high and exceed the preloading of the spring, the spring will be compressed as the cable mast moves, transferring motion to the spring tab linkage which in turn deflects the spring tabs. The spring tabs are deflected in an opposite direction with relation to the elevator surface travel and provide a means of overcoming the high control forces. Unlike the rudder combination trim and spring tab, the elevator spring tabs and trim tabs are separate surfaces and the movement of one does not effect the other.

Attached to the cable mast on the elevator torque tube arm is a cam which rides on a roller on the elevator bungee arm. This arm is spring loaded by a tension spring attached to one end of the arm and to the fuselage structure. Rotation of the elevator torque tube varies the position of the cam, thus varying the tension of the spring. By the roller on the cam bungee arm being offset from the rotational axis of the cam, the variable spring force is thus transferred into a variable moment about the elevator torque tube. This variable moment is transferred into the spring tab control system, and also into the elevator control system through the connecting spring attachment. See figure 23 for elevator spring tab system.

Elevators (See figure 7).

The right and left elevators are identical and are interchangeable with each other. The elevators consist of a spar and rib assembly with a reinforced sheet aluminum alloy covering, and each is attached to the horizontal stabilizer at four hinge points with anti-friction bearings. Each elevator surface is connected to the elevator control system by a horn attached to its torque tube. These horns are equipped with ten mounting holes of which one set of seven holes is used for the left elevator and another set of seven holes for the right elevator (refer to procedure on "Elevator Replacement" for further information).

Each elevator is equipped with a separate spring tab and trim tab, and is statically and dynamically balanced. Mass balancing weights are attached spanwise at the inboard leading edge of each elevator and are accessible from the inboard closing rib at the leading edge. These weights are adjustable and so arranged that the balance may be readily changed. A counterbalance arm extends forward from the elevator leading edge at elevator station 208 into a cut-out in the horizontal stabilizer. Static dischargers are attached to the elevator trailing edge to dissipate static electricity into the air. Access openings are provided on the bottom of the left elevator and the top of the right elevator for interior inspection. The elevators in addition to being interchangeable from left to right are also interchangeable between airplanes.

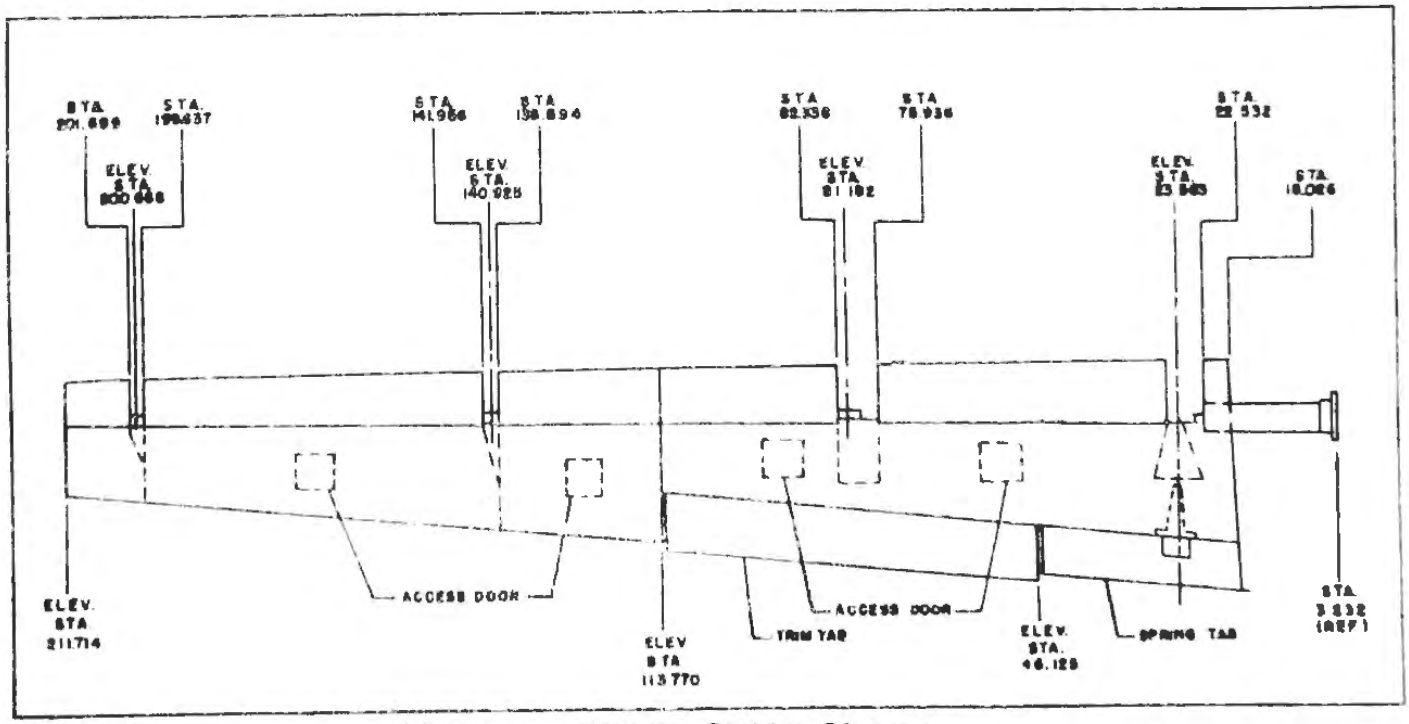


Figure 7. Elevator Station Diagram

Elevator Torque Tube (See figure 8).

The elevator torque tube is mounted laterally in the aft end of the fuselage at station 913.8. A cable mast (spring tab arm) is mounted on bearings on the left end of the torque tube and is free floating about the torque tube. The control cables running aft from the control column are attached to the ends of this mast. This cable mast is connected by a preloaded spring to a bellcrank which is bolted to the left outboard end of the torque tube. Attached to the other end of the bellcrank from the preloaded spring attachment is an arm which is connected to the spring tab linkage. A short push rod connects the center of this arm with the cable mast, so that motion from the cable mast is transferred to the spring tab system when control forces exceed the preload of the spring and the spring is compressed.

When the control cables move the cable mast it will in turn drive the bellcrank attached to the torque tube, through the preloaded spring attachment and rotate the torque tube. Two levers, which are attached to the torque tube near the center of its span, transfer this torque tube movement to attached push-pull rods, which in turn move the elevator surfaces. Located between the left lever and the cable mast is a quadrant which is attached to the torque tube. Attached to the two extremities of this quadrant are the adjustable torque tube stops. These stops, which strike against a bumper on the fuselage, limit the angular travel of the elevator torque tube to 70 degrees, of which 43 1/2 degrees are elevator "up" travel and 26 1/2 degrees are elevator "down" travel. The aft top section of this quadrant is spring loaded, and a hole near the forward end of this section engages the lock pin of the gust lock when the gust lock system is engaged. When the gust lock is engaged in this section of the quadrant, the elevator torque tube will be locked in a neutral position.

Attached to the cable mast below the elevator torque tube is a cam. This cam rides on a roller on the elevator bungee arm. The cam is adjusted so that the scribe mark on the cam is in line within ± 5/16 inch of the center line of the roller when the elevator torque tube is in neutral. Refer to "Elevator Bungee" for further information.

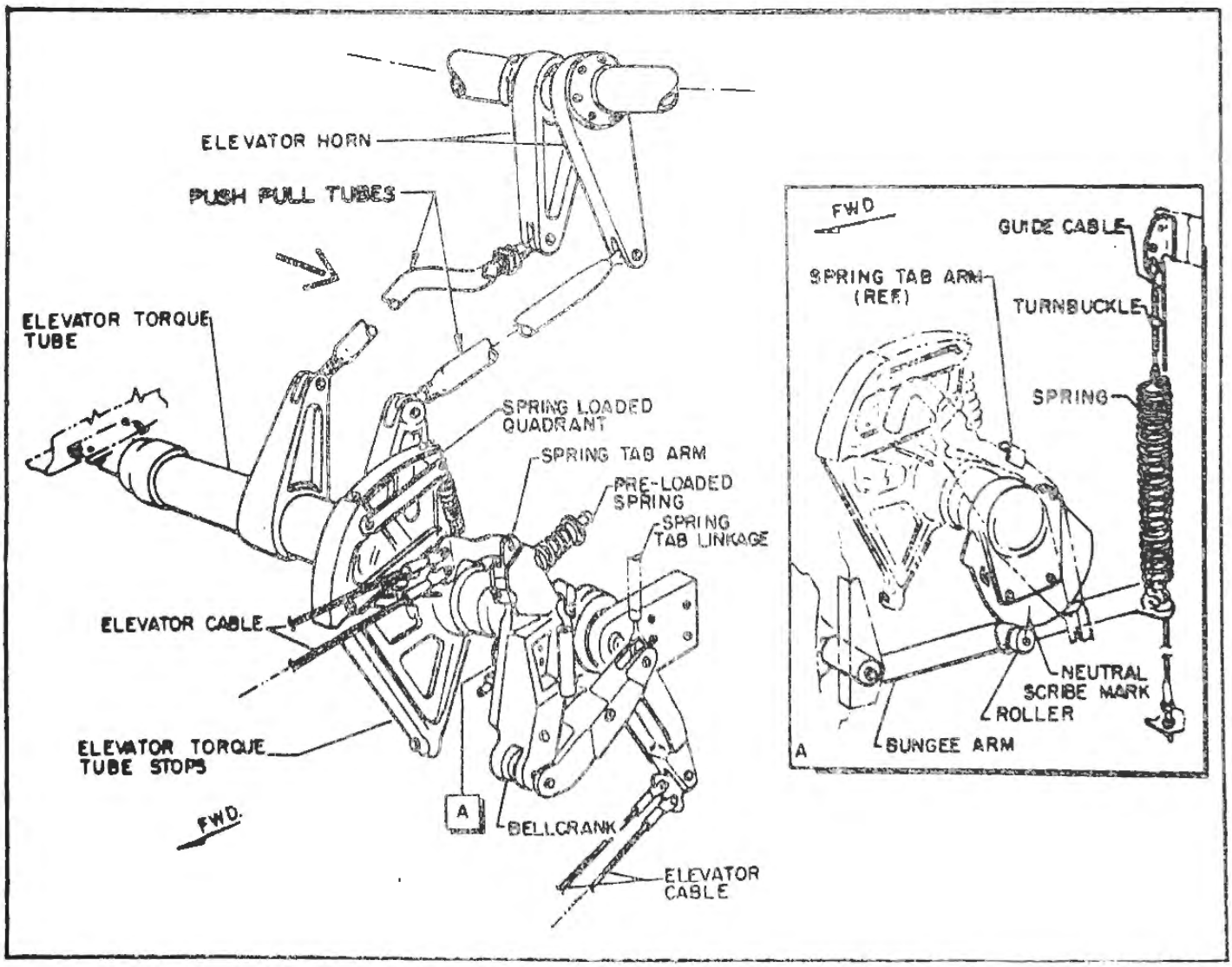


Figure 8 Elevator Torque Tube

Elevator Bungee (See figure 9).

The elevator bungee is installed in the aft end of the fuselage at the elevator torque tube. Its purpose is to reduce the forces required to land and maneuver the airplane.

The bungee is a spring mounted vertically in the aft end of the fuselage, and which acts through a cam to apply a variable force to the elevator control system. The top end of the spring is attached to the fuselage structure through an adjustable turnbuckle, and the bottom end is attached to the aft end of the cam bungee arm. The forward end of this arm is hinged to the fuselage structure. A roller on the tube engages a cam which is fixed to the cable mast on the elevator torque tube. As the elevators are deflected and the elevator torque tube is rotated, the cam varies the spring tension Since the center of the roller is offset from the rotational axis of the cam, the variable spring force is thus transferred into a variable moment about the elevator torque tube This variable moment is transferred into the spring tab control system, and also into the elevator control system through the connecting spring attachment. Adjustment of the bungee system is accomplished by means of the turnbuckle at the top of the spring. Shortening the turnbuckle increases the spring preload and lengthening it decreases the spring preload.

The reduction in required control forces is accomplished in two ways. During the landing approach, the elevator setting is such that the bungee puts a forward column force into the control system. This forward column force is reacted by a trim tab setting in the direction to apply an aft column force. As the landing is continued and more up elevator deflection is applied, the force applied by the bungee drops to zero, leaving the assisting aft column force that had been applied by means of the trim tab. This eliminates the need to retrim the airplane during the period when the pilot is occupied in completing the landing.

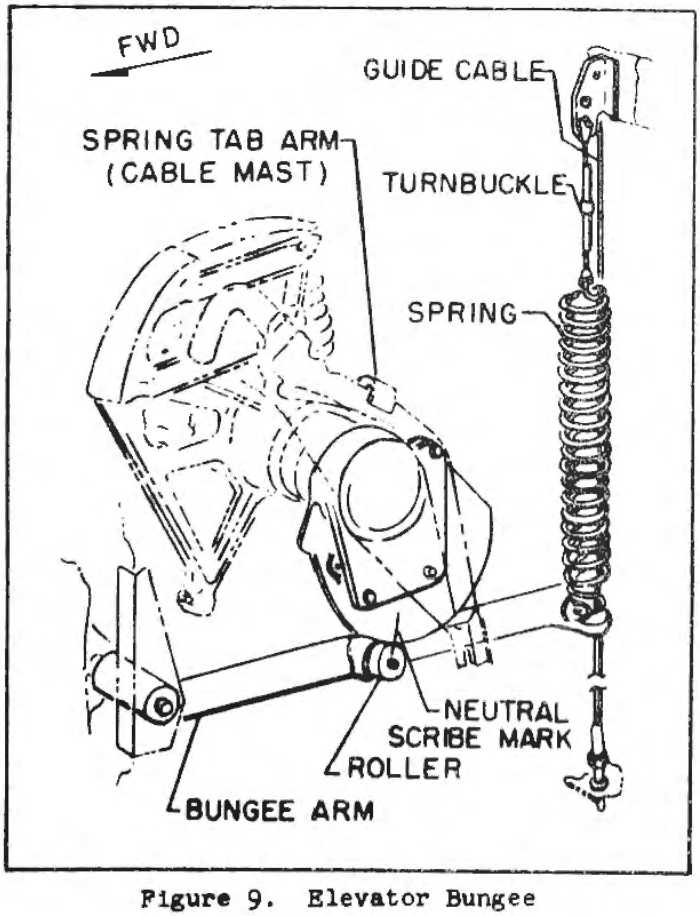


Figure 9. Elevator Bungee

Control Column (See figure 29).

Dual control columns are provided in the pilots' compartment. These control columns are used to operate the elevator and aileron control systems. Each column is an intergral part of a torque tube hinged below the pilots' compartment floor. The fore and aft lever action of the control columns is used to control the elevator control system, while the turning movement of the wheels attached to the heads of the columns controls the aileron control system. A horn, which is also an integral part of the torque tube, extends downward and connects to the elevator control system cables. Located on the aft side at the base of the pilot's column is a tab with a 3/8 inch hole through it. This hole is used as a rigging pin hole in conjunction with holes in the adjacent floor beams. A rigging pin inserted through the hole in the column tab and the holes in the floor beams will hold the control columns in a neutral position for rigging or checking the elevator control system. Located on the forward side of the pilot's column are two adjustable column stops which limit the fore and aft travel of the control columns.

The aileron control wheel on each column actuates a sprocket and chain within the head of the control column. Two 1/8 inch 7 x 19 flexible carbon steel cables connect the inboard ends of the chains in the columns together and are adjusted for tension by turnbuckles located on the forward side of the tube below the floor. Rubber rings are used to tie the two turnbuckles together and prevent them from vibrating against each other. Two 1/8 inch cables connect the outboard end of the chain in each column with the aileron stepdown bellcranks. Stops are built into the heads of the columns which limit the throws of the control wheels in each direction. These stops are positioned so that the aileron bellcrank stops are engaged 5 degrees before the stops in the control wheels, thus giving spring back to the wheels in the last 5 degrees of rotation in each direction. Refer to "Aileron Control System" for a description of the aileron system.

ELEVATOR TRIM TAB SYSTEM - GENERAL (See figure 19).

The elevator trim tab system is controlled from either of two wheels mounted on the sides of the pedestal near the forward end. The left wheel is positioned so that it is accessible to the pilot, while the right wheel is accessible to the co-pilot. These control wheels are connected by a gear box, chain and torque tube shaft to a cable drum under the floor. Single 3/32 inch 7 x 7 flexible steel cables running aft connect this drum under the floor with similar drums in the horizontal stabilizer. A bus cable of the same size connects these two stabilizer cable drums, thus completing the cable loop from the drum below the pilots' compartment floor. These horizontal stabilizer drums are connected by torque tubes to the trim tab actuators on the elevator hinge brackets. Connected to the aft end of each actuator is a push-pull rod which actuates the trim tab on its respective elevator trailing edge. The elevator trim tab actuator and control push rod is rigged so that they provide a balance action at the trim tabs when the elevators are moved. This balance action is approximately 0.2 degree lag for every 1.0 degree of elevator travel.

Two methods of checking the trim tab servo travel is provided. These may be made with the elevators in the full throw position or the 15 degree position from neutral. With elevator at full up throw the trim tabs will be down 7 ± 1 degrees and with elevator at full down throw the trim tabs will be up 4½ ± 1 degrees. The alternate method of checking for servo travel is to hold the elevators in the 15 degree up position and checking that trim tabs are 3 ± 3/4 degrees down; then holding the elevators in the 15 degree down position and checking that trim tabs are 3 ± 3/4 degrees up.

ELEVATOR TRIM TAB SYSTEM OPERATION (See figure 19).

The elevator trim tab system is operated by either of two control wheels mounted on the sides of the pedestal near the forward end. Rotation of these wheels in either direction drives a gear box in the pedestal. Motion from the gear box is transmitted by a chain and sprockets to a torque tube shaft below the pedestal. This shaft in turn rotates a cable drum under the right side of the pilot's compartment floor. Motion from this cable drum is transmitted aft by two cables to the two drums mounted on the aft side of the horizontal stabilizer front spar. One of these cables branches to the cable drum in the left side of the stabilizer and one branches to the cable drum in the right side. A third or bus cable connects these two drums together. Rotary motion is transferred from the cable drums to their respective tab actuators (screwjacks) by torque tubes. These tab actuators convert this rotary motion to fore and aft movement and operate the trim tabs up or down by a connecting push-pull rod. The attaching point of this push-pull rod on the tab actuator is so located that when the elevators are moved, the tab will have a 0.2 degree lag for every 1.0 degree of elevator travel. This lag will deflect the tab in the opposite direction of elevator travel and add assist to the elevator controls (see figure 27).

Elevator Trim Tabs (See figure 7).

The elevator trim tabs are of all metal construction and are attached to the trailing edge of the elevators outboard of the spring tabs by means of a piano type hinge. Since the elevators are interchangeable from right to left sides, the piano hinge on the left elevator will be on the top side and on the bottom on the right side. Two hinge pins attach the trim tab to the elevator and are accessible for removal or installation by removing a small section of hinge plate. Two small removable channels are located on the opposite side of the tab leading edge from the hinge pin. The removal of these channels, one on each side of the tab actuating push rod, permit access to the push rod attaching bolt. This trim tab is controlled by the operation of the elevator trim tab system, and it is completely independant of the adjacent spring tab.

NOTE: The left and right trim tab actuators are not interchangeable.

Elevator Trim Tab Control Mechanism (See figure 25).

The elevator trim tab control mechanism is located on the sides of the pedestal near the forward end and is accessible to both the pilot and co-pilot. This control mechanism consists of a control wheel and dial on each side of the pedestal, two gear boxes, a single shaft connecting the two gear boxes, two sprockets, a chain, a torque tube shaft, link adjuster assembly, and a cable drum. Rotation of either control wheel drives its respective gear box and the shaft which connects the two gear boxes; thus when one wheel is rotated, the other wheel will also rotate in the same direction. Motion from the connecting shaft is transferred by the sprocket on the shaft to a chain which drives the torque shaft below the pedestal and pilots' compartment floor. This torque shaft in turn rotates the cable wound drum at the end of the shaft. A chain tension adjusting link is connected to the torque shaft to adjust the tension on the chain connecting the cable drum torque shaft with the control wheels interconnecting shaft. Internal stops within the left gear box limit the rotation of the control wheels to the maximum "NOSE UP" and "NOSE DOWN" positions.

Elevator Trim Tab Actuators (See figure 10).

The elevator trim tab actuators are mounted, one on each side of the horizontal stabilizer, on the second elevator hinge bracket outboard of the fuselage center line. These actuators are screw-jack type mechanisms which convert rotating movement of the horizontal stabilizer cable drums and connecting torque tubes to "in" and "out" movement of the fork ends of the units. The actuators consist of a housing with four mounting bolt holes, an interval screw-jack assembly and bearing, a dust cover boot, a fork fitting on the aft end of screw jack assembly, and two lubrication fittings in the housing. Rotation of the shaft end of the actuator turns the interval screw jack assembly which in turn moves the fork end "in" or "out" depending on the direction of shaft rotation. Refer to Chapter 14 for information on lubrication of the tab actuator.

NOTE: The tab actuators, unlike the tabs, are not interchangeable from right to left and vice-versa.

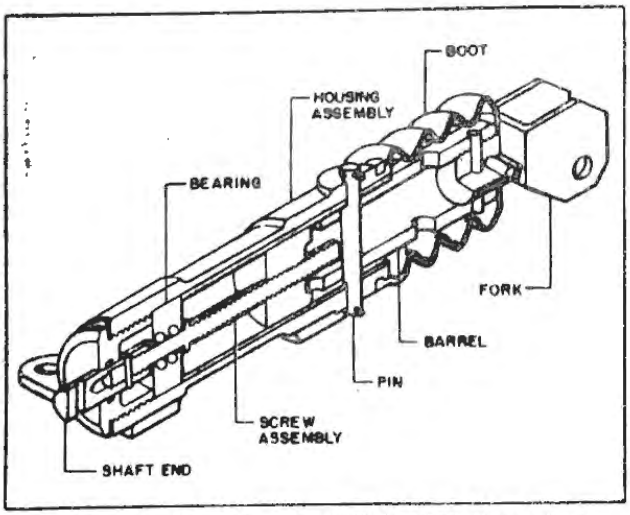


Figure 10. Elevator Trim Tab Actuator

AILERON CONTROL SYSTEM - GENERAL. (See figure 17).

Aluminum alloy covered ailerons are used to provide lateral control of the airplane, and are controlled from the pilots' compartment by the turning movement of the control wheels on the dual control columns. A hydraulic power boost system is incorporated in the aileron control system to reduce pilot effort and to reduce the amount of wheel deflection. The aileron control system is so designed that for a given amount of system cable travel, the aileron which moves up will travel twice as far as the aileron which moves down.

Dual 1/8 inch 7 x 19 flexible preformed carbon steel cables are used to connect the inboard ends of the chains in the control columns together, and to connect the outboard ends with their respective step-down bellcranks in the nose wheel well. Single 3/16 inch flexible preformed carbon steel cables connect the step-down bellcranks with the forward quadrant on the aft side of the center wing rear spar. 3/16 inch cables also form independent cable circuits from the aft quadrant to the bellcrank in each outer wing forward of the aileron.

Turnbuckles in the cables connecting the two control wheels are located on the forward side of the control column interconnecting torque tube. The turnbuckles in the cables connecting the control wheels with the step-down bellcranks are accessible through the side pressure panels in the nose wheel well. The turnbuckles in the 3/16 inch fuselage cables are accessible through the forward heater hatch. The turnbuckles in the wing cables are located just outboard of the wing splice and are accessible by pulling the wing flap shutter doors down.

AILERON CONTROL SYSTEM OPERATION (See figure 33).

The aileron control system is operated by the turning movement of the control wheels. Each of these control wheels drives a sprocket and chain within the control column head. Dual cables connect the inboard ends of the chain in each column, thus when one wheel is turned, these connecting cables turn the other wheel. Movement is transferred from the outboard ends of the chain in each column to attached dual cables which in turn move step-down bellcranks located on each side of the nose wheel well, just forward of the pilots' compartment bulkhead, station 212. From these bellcrank, single cables transfer the cable movement to the forward aileron quadrant which is pivoted on the aft quadrant.

With the power boost system on, the forward quadrant will displace the boost system control valve, through an interconnecting push rod, permitting hydraulic fluid to move the actuating boost cylinder. The piston rod of this cylinder moves the forward quadrant which in turn drives the aft quadrant to which it is pivoted. The forward quadrant acts as a walking beam between the control valve push rod connection and the actuating cylinder piston rod connection so that when the cylinder catches up to the quadrant movement, the quadrant will be in neutral and the control valve centered. Refer to Aileron Power Boost System for further information.

Movement is transferred from the aft quadrant through independent cable circuits to the bellcranks in the outer wings. These bellcranks in turn transfer the cable movement to up and down travel of the aileron surfaces through connecting push rods. The cable circuits are so rigged that the rotation of the control wheels to the left (counter-clockwise) will raise the left aileron and lower the right aileron. Rotation of the control wheels to the right (clockwise) will produce reverse movement of the ailerons. Stops in the control column hubs and at the wing bellcranks limit the system travel.

Aileron Control Wheels.

Refer to "Control Column" of this chapter for a description of the control columns and control wheels.

Aileron Quadrants (See figure 34).

Two aileron quadrants are located on the aft side of the center wing rear spar and are accessible through the fuselage rear spar access hatch. The aft quadrant, to which the wing cables are attached, is pivoted from the spar structure. A small quadrant, to which the fuselage cables are attached, is pivoted on the forward side of the larger aft quadrant. The power boost system control valve actuating rod and the actuating cylinder piston rod are both connected to the forward quadrant. Two adjustable stops on the aft quadrant limit the free travel of the forward quadrant to plus or minus 3 degrees (plus or minus 3/8 inch at the rim of the control wheel).

A cable rig compensator is mounted above the forward quadrant and rides on the rim of this quadrant. Located below on the left side of the aft quadrant is the aileron control system gust lock which, when engaged, locks the aileron quadrant and aileron surfaces in a neutral position.

Cable Rig Compensator (See figure 34).

A cable rig compensator is mounted above the forward aileron quadrant and has a spring-loaded bearing and shaft which rides on the rim of this quadrant. This compensator compensates for the reaction from the cable rigging load, which moves to the side of the quadrant pivot point in either direction of quadrant travel, by tending to return the quadrant to neutral. This reaction, from the rigging load shifting to the side of the quadrant pivot point, would also hold the control valve open and continue moving the quadrant to its extreme of travel if it were not for the compensator which exerts a load on the quadrant, causing it to have tendency to return to neutral whenever the rigging load shifts.

Wing Bellcranks (See figure 17).

The aileron wing bellcranks are located one in each outer wing at station 47± forward of the aileron control surfaces. Each bellcrank is mounted on bearings just forward of the wing rear spar and is accessible through the access doors in the outer wing lower surface. The outer wing cables are connected to the forward and aft arms on the bellcrank while the small arm just forward of the hinge point is connected to the push rod which actuates the aileron surface. An adjustable stop, which is attached to a bracket on the forward side of the wing rear spar, limits the amount of bellcrank travel. One of these stops is located at each outer wing bellcrank. The up travel of the right aileron and the down travel of the left aileron is limited by the adjustment of the stop at the left wing bellcrank, while the right wing bellcrank stop limits the up travel of the left aileron and the down travel of the right aileron.

Ailerons (See figure 11).

The ailerons are the slot lip-type control surfaces, and are of a conventional spar and rib type construction with an aluminum alloy skin. Each aileron is statically and dynamically balanced. The balancing weights, which are distributed spanwise along the leading edge, balance the aileron statically, while the aileron vane balances it dynamically. A combination trim and balance tab with irreversable balance controls is installed on the inboard trailing edge of each aileron. Each aileron is hinged at its junction with the upper surface of the wing trailing edge by three conventional bearing bolt type hinge attachments. A vane is attached to the lower surface of the aileron leading edge to provide a smooth flow of air across the lower surface of the wing and aileron when it is in the up position. A nylon sealing strip covers the space between the trailing edge of the wing and the upper surface of the aileron to obtain a smoother flow of air while the aileron is in the up position. Three static dischargers are attached to the aileron trailing edge to dissipate static electricity. The ailerons are interchangeable between airplanes, but unlike the elevators are not interchangeable from left to right.

AILERON POWER BOOST SYSTEM - GENERAL (See figure 34).

The aileron power boost system is used to reduce the aileron control wheel deflection, and to reduce the load on the wheel when it is turned. The entire boost system, with the exception of the two control switches on the pedestal, is located on the aft side of the center wing rear spar, and is accessible through the fuselage rear spar access hatch. The boost system consists of two quadrants, a hydraulic actuating cylinder, a control valve, a filter, a filtered orifice, a solenoid operated hydraulic shut-off valve, a by-pass valve, and a solenoid operated emergency disconnect mechanism.

The aft aileron quadrant is pivoted on the aft side of the center wing rear spar and the forward quadrant is pivoted on this aft quadrant. An adjustable push rod connects the lower end of the forward quadrant lever with the control valve. The piston rod of the actuating cylinder is connected to the lower end of the forward quadrant. This piston rod connection is above the control valve push rod connection and below the forward quadrant pivot point so that a walking beam effect is produced when the control system is operated.

Hydraulic power for the boost system is supplied by the 1500 psi closed center hydraulic system and is controlled by the boost system's solenoid operated shut-off valve.

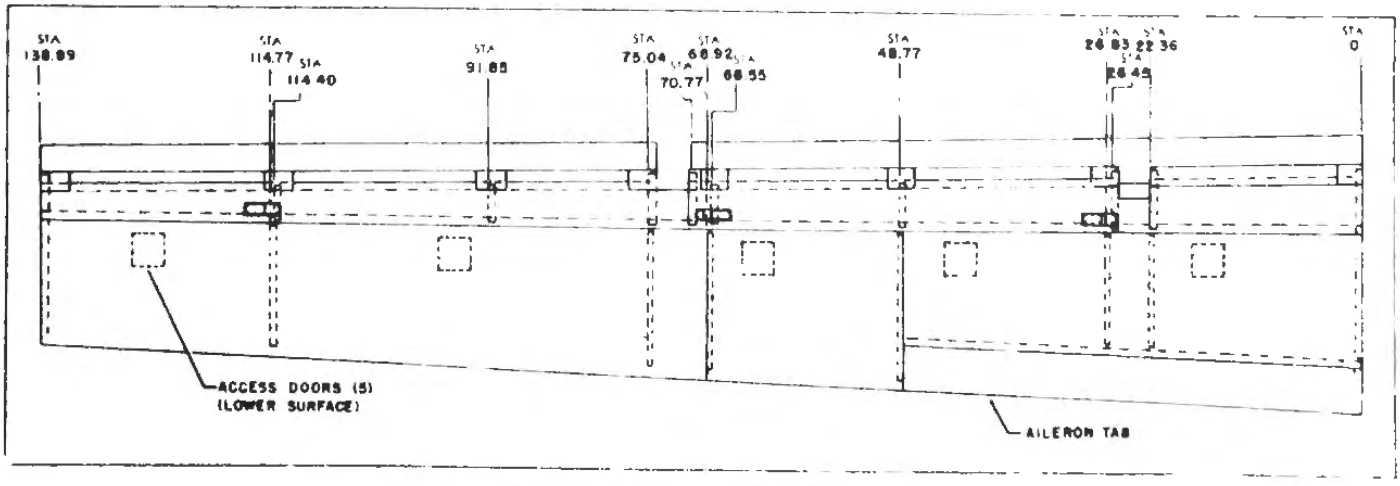


Figure 11. Aileron Station Diagram

AILERON POWER BOOST SYSTEM OPERATION.
(See figure 33).

The aileron power boost system is used at all times when the aileron control system is operated, but may be disconnected from the aileron control system if a malfunction should occur in any part of the boost system.

Since power for the aileron boost system is supplied by the closed center hydraulic system, the boost will be operative only so long as the closed center system is pressurized. Depressurizing the hydraulic system by means of the "HYDRAULIC BY-PASS VALVE", located on the floor to the left of the pilot's chair, will result in loss of hydraulic power to the aileron boost system as the pressure in the accumulator drops through the operation of the boost system or by the controlled bleeding in the neutral position. Once the accumulator pressure has dropped, aileron control will be the same as with aileron boost system shut-off.

With the "AILERON BOOST" control switch on the pedestal in the "ON" position and the closed center hydraulic system pressurized, the power boost system will be automatic in operation anytime the control system is moved. Hydraulic pressure from the closed center system is directed through the solenoid operated shut-off valve and boost system filter to the four-way slide type control valve. A controlled bleed is provided at the neutral position of this valve so that approximately ½ system pressure is maintained on each side of the actuating cylinder at neutral position. A tee connection between the solenoid shut-off valve and the filter also directs hydraulic pressure to the pressure operated by-pass valve displacing the poppet within the valve closing the by-pass between the two sides of the actuating cylinder.

Slight motion of the forward quadrant by the control wheel in pilots' compartment will displace the four-way control valve through the connecting push rod. Hydraulic fluid will then be directed into the actuating cylinder boosting the forward quadrant which drives the aft quadrant and moving the ailerons in the direction indicated by the movement of the control wheel. When the ailerons reach the position determined by the control wheel position, the walking beam action of the forward quadrant will have returned the control valve to a position near neutral so that sufficient differential pressure is maintained across the actuating cylinder piston to hold the load. Due to the sensitivity of the control valve, a filtered orifice is placed across the two lines to the actuating cylinder to equalize cylinder pressure and give good centering qualities to the boost system.

When the aileron control system is operated with the boost system off (not pressurized) hydraulic fluid in the actuating cylinder will be by-passed from one side of the cylinder to the other through the by-pass valve which is open when the boost system is not pressurized.

A solenoid operated mechanical disconnect mechanism is provided in the boost system so that the actuating cylinder can be disconnected in case of any type of malfunctioning of the boost system. This disconnect mechanism is operated by raising the guard over the "AILERON BOOST-EMERG. DISCONNECT" switch on the pedestal and holding this switch "on" momentarily. This will energize the disconnect solenoid permitting the tension spring to disengage the boost system emergency disconnect mechanism. The pilot will then have directional control of the ailerons except for plus or minus 3 degrees of wheel play due to the setting of the stops at the forward quadrant. With the boost system disconnected, the actuating cylinder will be free to move with the forward quadrant. The emergency disconnect mechanism cannot be re-engaged from the pilots' compartment, but must be manually re-engaged from the ground. A 5/8 inch inspection hole is provided in the disconnect mechanism support to visually determine that disconnect is engaged. Disconnect will be engaged when the white rivet head and spacer on the cylinder pivot arm are visible through the inspection hole.

It is not necessary to disconnect the aileron boost system due to a loss of hydraulic pressure, for there is no noticeable difference in the effort required to operate the controls in this condition and in the disconnected condition. The emergency disconnect is for emergency disengagement of the boost system in case of mechanical "jamming". To re-engage the boost system or to determine whether the boost disconnect is engaged, refer to index of this chapter for procedure.

Actuating Cylinder (See figure 34).

The actuating cylinder, which is controlled by the boost system control valve, has a balanced piston design so that when the valve is in neutral position the balance pressure on each side of the piston will not result in an unbalanced force in the aileron control system. The head end of the cylinder is attached to the structure at the emergency disconnect mechanism, while the piston rod end is attached to the forward quadrant at a point below the pivot of the forward quadrant on the aft quadrant. Thus the actuating cylinder provides both the feel reaction for the pilot and the boost power for the aileron.

The actuating cylinder consists of a barrel, two cylinder heads bottomed on the barrel and secured by check nuts, a piston and piston rod, and an adapter and bearing end fitting. Each cylinder head contains a port for attaching the operating hydraulic line, a bleeder plug, and an oiler fitting for lubrication of the felt wiper ring. The adapter fitting on the piston rod end is adjustable within ± ¼ inch and is secured in position by a check nut and a lock key. The bearing end is secured in position by a safety wired check nut.

Normally, this cylinder will not require servicing between overhaul periods, but if leakage should occur or the cylinder malfunctions replace it with a serviceable unit.

GUST LOCK SYSTEM - GENERAL (See figure 31).

A gust lock system is provided on the airplane to lock the aileron, rudder and elevator control surfaces in neutral, and prevent them from being moved by gusty or windy weather conditions. This system consists of a gust lock handle in the pilots' compartment which actuates spring loaded control gust locks at the main aileron quadrant, elevator torque tube and the rudder through a series of push rods and cables.

GUST LOCK SYSTEM OPERATION (See figure 31).

The gust lock system is operated by moving the gust lock handle from its stowed or unlocked position under the pilot's sliding window, inboard and forward until engaged on the locked position detent. This handle actuates two push rods, a bellcrank and a quadrant which are located behind the soundproofing trim and the pilot's console. The quadrant behind the pilot's console in turn actuates the quadrants on the gust locks at the center wing aileron quadrant, elevator torque tube and at the rudder by means of a cable system, extending the lock pins within the gust locks. The controls are then moved about an estimated neutral until locked. Automatic engagement of the lockpins in the controls is accomplished by using spring-loaded plungers on the aileron and rudder gust locks and a spring loaded quadrant on the elevator torque tube.

When the gust lock handle is in the locked position, the release lever is approximately 3/8 inch from the aft face of the pilot's control wheel in full view of the pilot. This makes it impossible for the pilot to attempt a take-off with the controls locked. The gust lock system is released by tripping the release lever on the end of the gust lock handle and returning it to the unlocked or stowed position. This handle will automatically return toward the unlocked position, due to the spring action of the gust locks, when the release lever is operated. An unlocked position detent is provided on the rack assembly at the hinged end of the handle to hold the system in an unlocked psoition. The gust lock system may also be disengaged by exerting a 40 pound pull on the co-pilot's control column wheel. Refer to "Gust Lock System Adjuatment" of this chapter for procedure on adjusting required pull on co-pilot's control wheel.

WARNING

The elevator control columns must not be permitted to free fall forward against the column stop when gust lock is released or when column is released from neutral. The elevator bungee puts a forward force into the control columns and damage may result to the structure or personnel.

Gust Locks (See figure 16).

The gust lock assemblies used to lock the aileron, rudder and elevators are identical in appearance, but are not interchangeable between the three control systems. The rudder and aileron gust locks are identical in construction and vary only in the position of the cable guards. The body of the gust locks used for the rudder and aileron controls houses a rack with an internal spring-loaded plunger or pin and a gear type shaft. Mounted externally on this shaft is a cable wound quadrant. A compression spring and retaining collar are mounted externally on the rack. Rotation of the quadrant by the gust lock system cables turns the gear type shaft, which in turn moves the rack and extends the spring-loaded plunger. The spring-loaded plunger will not extend past the body of the gust lock, even with the gust lock in the fully engaged position, until the mating part on the rudder or on the aileron quadrant is lined up. The compreasion spring behind the plunger will then engage the gust lock plunger in its respective surface control system. When the gust lock system is returned to the unlocked position, the external compression spring will assist in disengaging the plunger from the surface control system.

The construction and operation of the elevator gust lock is similar to that of the aileron and rudder except that the plunger is not spring-loaded, but is instead riveted to the internal rack. A spring loaded section of the elevator torque tube quadrant is compressed by the plunger when the elevator gust lock is actuated. This spring-loaded section of the elevator torque tube quadrant is in the section of elevator travel from elevator down to elevator neutral. Thus, the gust control locks can be put in the engaged or locked position only when the elevators are in neutral or anyplace between neutral and elevators down.

When necessary to replace a gust lock, refer to "Gust Lock System Adjustment" of this Chapter for procedure on rigging of control lock system.

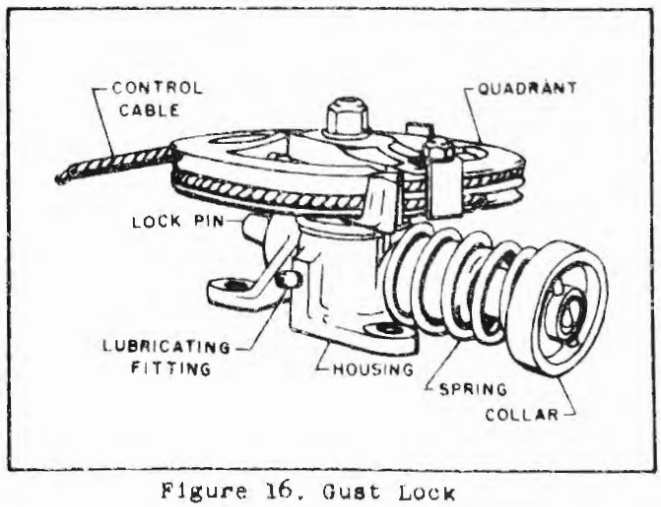


Figure 16. Gust Lock

AILERON TRIM TAB SYSTEM - GENERAL (See figure 17).

The aileron trim tab system is controlled from a knob on the pedestal which is readily accessible to both the pilot and co-pilot. The control knob is connected by a gear box, chain and torque tube shaft to a cable drum under the floor. Single, 3/32 inch 7 x 7 flexible preformed carbon steel cables run aft to the aft side of the center wing rear spar where one cable branches to the cable drum in the right outer wing and the other cable branches to the cable drum in the left outer wing. A single bus cable connects the two outer wing cable drums. Each of the outer wing tab cable drums is connected by a torque tube to its respective tab actuator. Connected to the aft end of each actuator is a push-pull rod which actuates the trim tab surface at the aileron inboard trailing edge.

The turnbuckles and vernier links used in adjusting the aileron trim tab system cables are located in the belly of the fuselage below the cabin floor and are accessible through the air conditioning hatch #80. Cable disconnect fittings are located in the outer wing panel just outboard of the wing splice and are accessible by pulling the wing flap shutter doors down.

AILERON TRIM TAB SYSTEM OPERATION (See figure 17)

The aileron trim tab system is controlled by the knob on the aft end of the pedestal. Rotation of this knob in either direction drives a gear box forward of the knob. Motion from the gear box is transmitted by a chain and sprockets to a torque tube shaft below the pedestal, which in turn rotates a cable drum under the right side of the pilots' compartment floor. Motion from this cable drum is transmitted by the cable system aft to the aft side of the center wing rear spar and then out each wing to the outer wing cable drums. A torque tube connected to the aft end of each outer wing cable drum actuates its respective trim tab actuator (screw jack). These actuators, which convert rotary motion to "in" and "out" motion, move the trim tab control push rods and deflect the trim tabs on the aileron inboard trailing edge.

Rotation of the "AILERON TAB" control knob to L. WING DOWN" will deflect the left aileron trim tab down and the right aileron trim tab up in relation to their respective surfaces. Rotation of the control knob to "R. WING DOWN" will deflect the trim tabs in an opposite direction from that produced by "L. WING DOWN".

Aileron Trim Tabs (See figure 1[illegible].

The aileron trim tabs are combination trim and balance tabs. The trim feature is manually controllable from the pilots' compartment while the balance of the tabs is fixed and is designed to provide a lagging tab movement of .[illegible] degree per degree of aileron surface movement. The tabs are of all metal construction having an aluminum alloy framework and skin, and are mounted on the inboard trailing edges of the ailerons at three hinge points. The aileron trim tabs are interchangeable between airplanes, and from left to right ailerons by reversing the position of the tab control push rod horn from one surface to the other.

Aileron Trim Tab Control Mechanism. (See figure 75).

The aileron trim tab control mechanism is mounted on the aft end of the pedestal in the pilots compartment and is accessible to both the pilot and co-pilot. This control mechanism consists of a control knob and dial, a gear box and chain sprocket, a chain, a torque tube shaft and chain sprocket, a chain tension adjusting link, and a cable drum. Rotation of the control knob drives the gear box and chain sprocket. Motion from the gear box is transmitted by the chain to the torque shaft, which in turn rotates the cable wound drum at the end of the shaft. Internal stops within the gear box limit the rotation of the control knob to an indicated 12 degrees on either side of neutral.

Due to the type of construction of the aileron tab control gear box, some roughness may be encountered when rotating this unit. This roughness is due to the beveled gears within the unit meshing and should not be cause for replacement if the system is working satisfactorily. The degree of roughness and/or backlash of the gears is controlled by the use of shims between the two sections of the gear box housing and on the chain sprocket shaft. These shims should be added or removed so that backlash is limited to a maximum of .006 inch. Normally this shimming is done at the overhaul base.

Aileron Trim Tab Actuators (See figure 15).

The aileron trim tab actuators are similar to the elevator tab actuators in construction and operation and vary only in shape of the fork end and number of lubrication fittings. The aileron tab actuator is equipped with a single lubrication fitting where as the elevator tab actuator has two. These aileron tab actuators are mounted on brackets on the outer trailing edge in the aileron cove area. Refer to "Elevator Trim Tab Actuators" for information on the construction and principle of operation of the tab actuators.

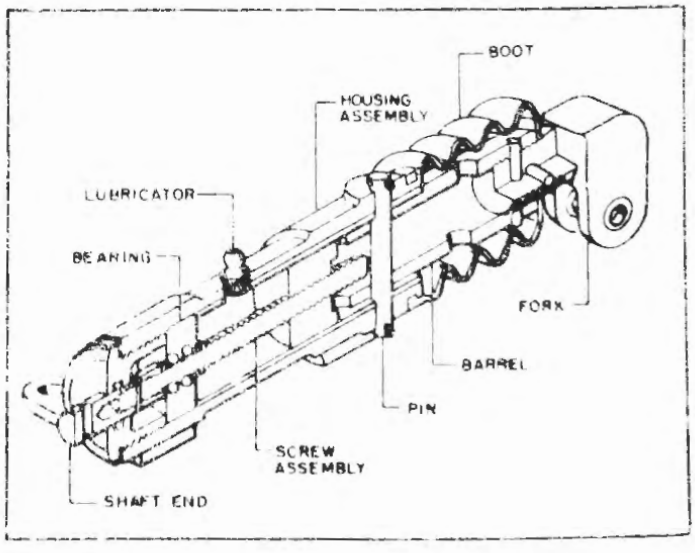


Figure 15. Aileron Trim Tab Actuator

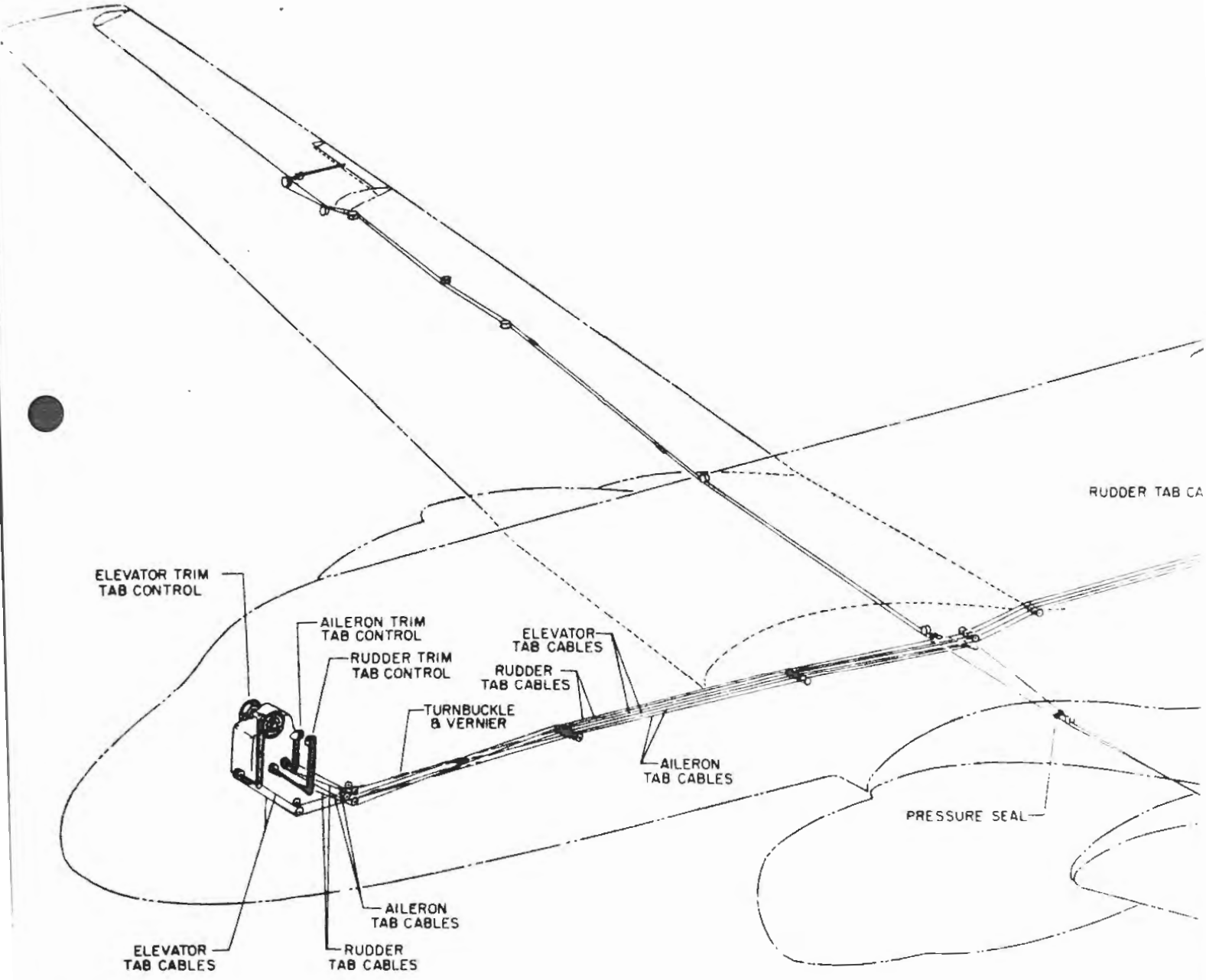
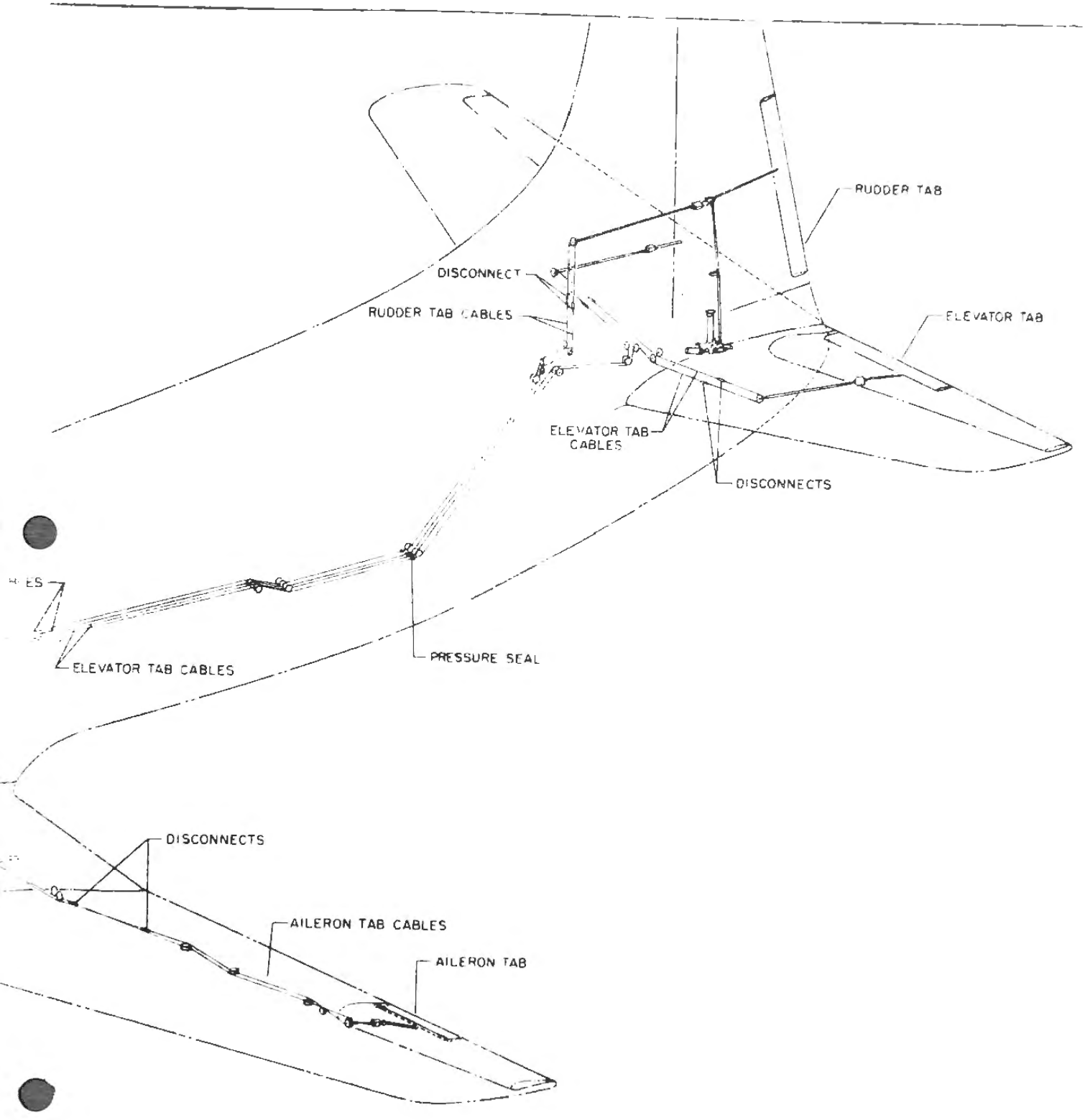


Figure 19. Trim Tab


RUDDER TAB
DISCONNECT
RUDDER TAB CABLES
ELEVATOR TAB
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DISCONNECTS
ELEVATOR TAB CABLES
PRESSURE SEAL
DISCONNECTS
AILERON TAB CABLES
AILERON TAB

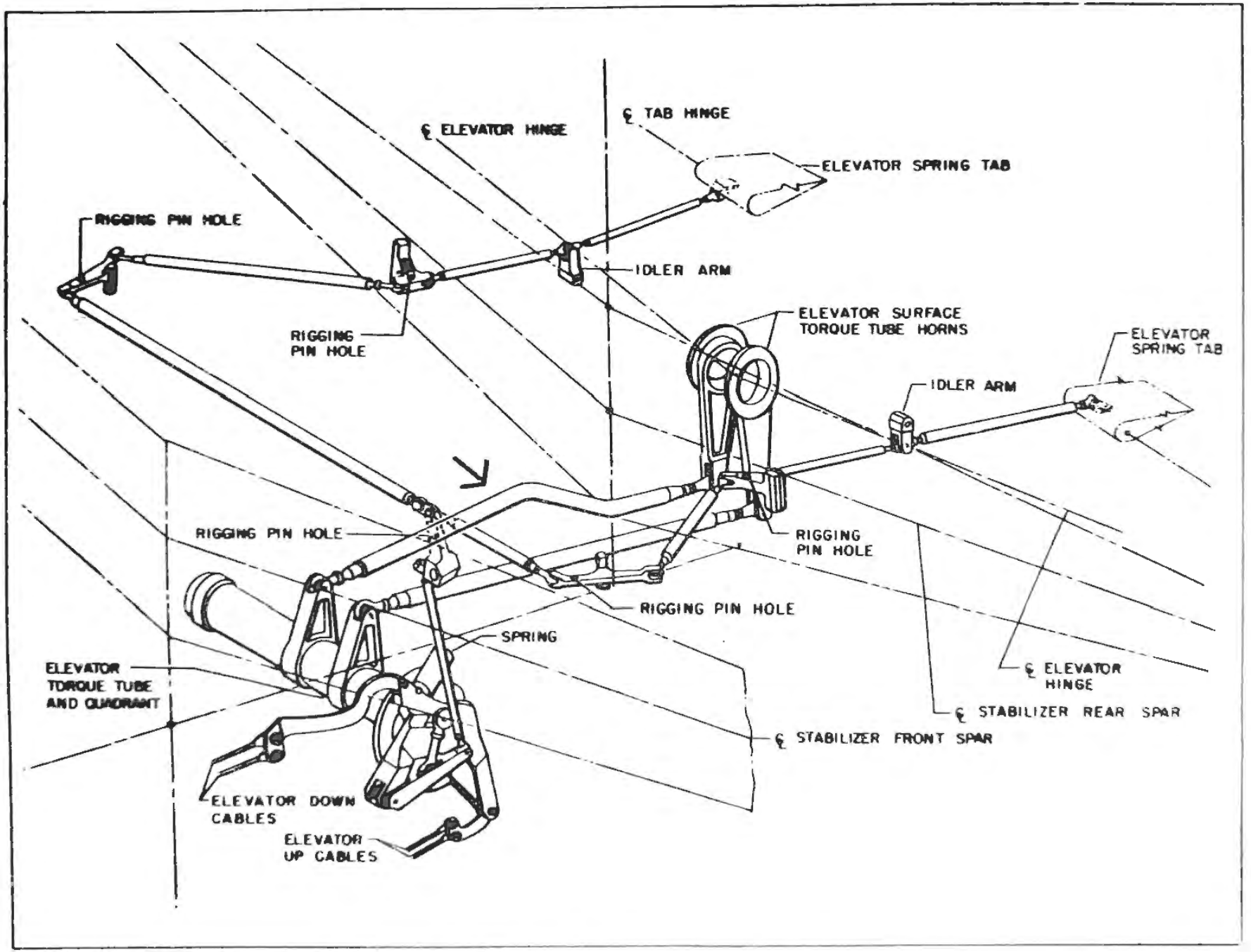


Figure 23. Elevator Spring Tab Control System.

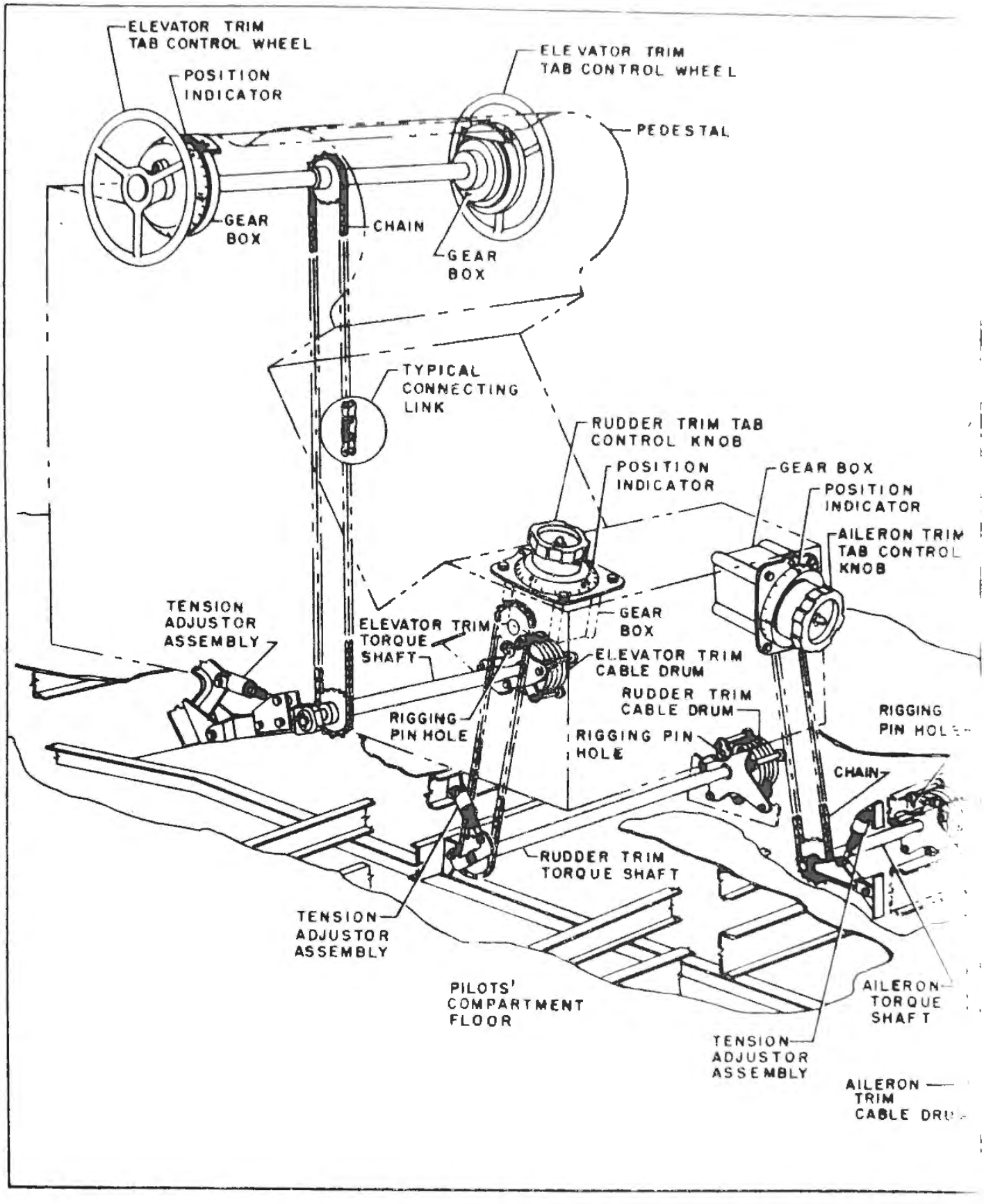


Figure 25. Trim Tab Controls Mechanisms

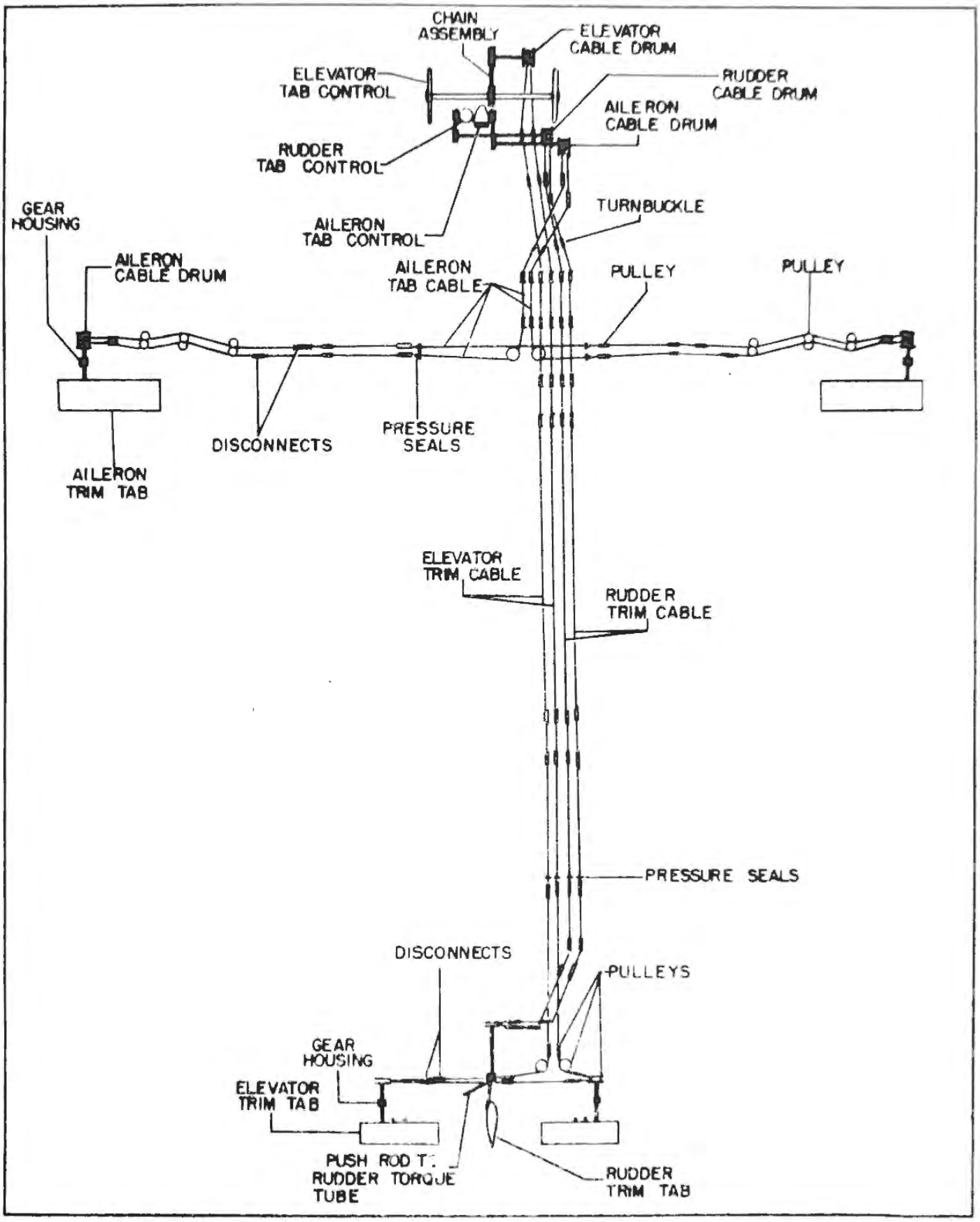


Figure 27. Surface Controls Trim Tab Schematic

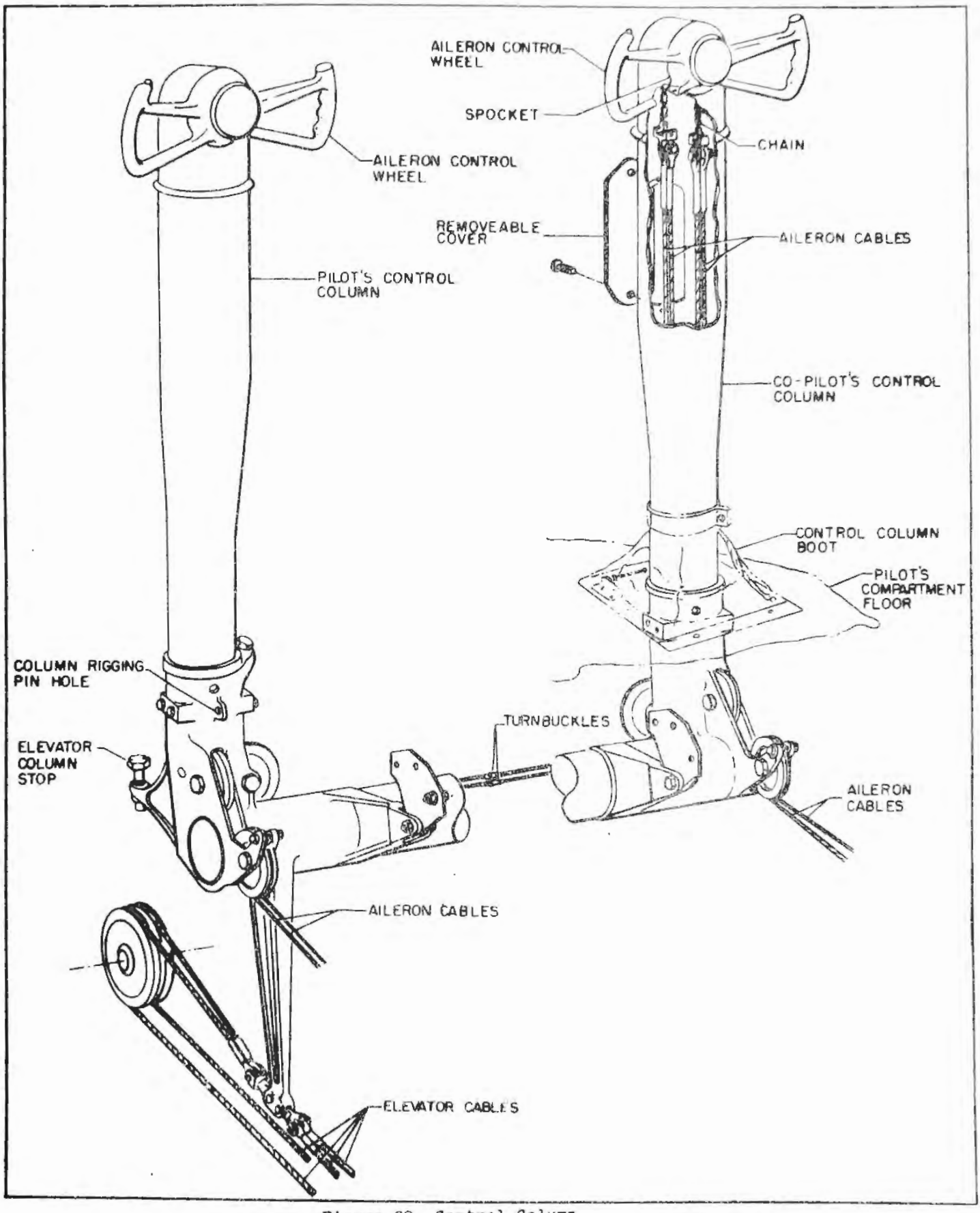


Figure 29. Control Column

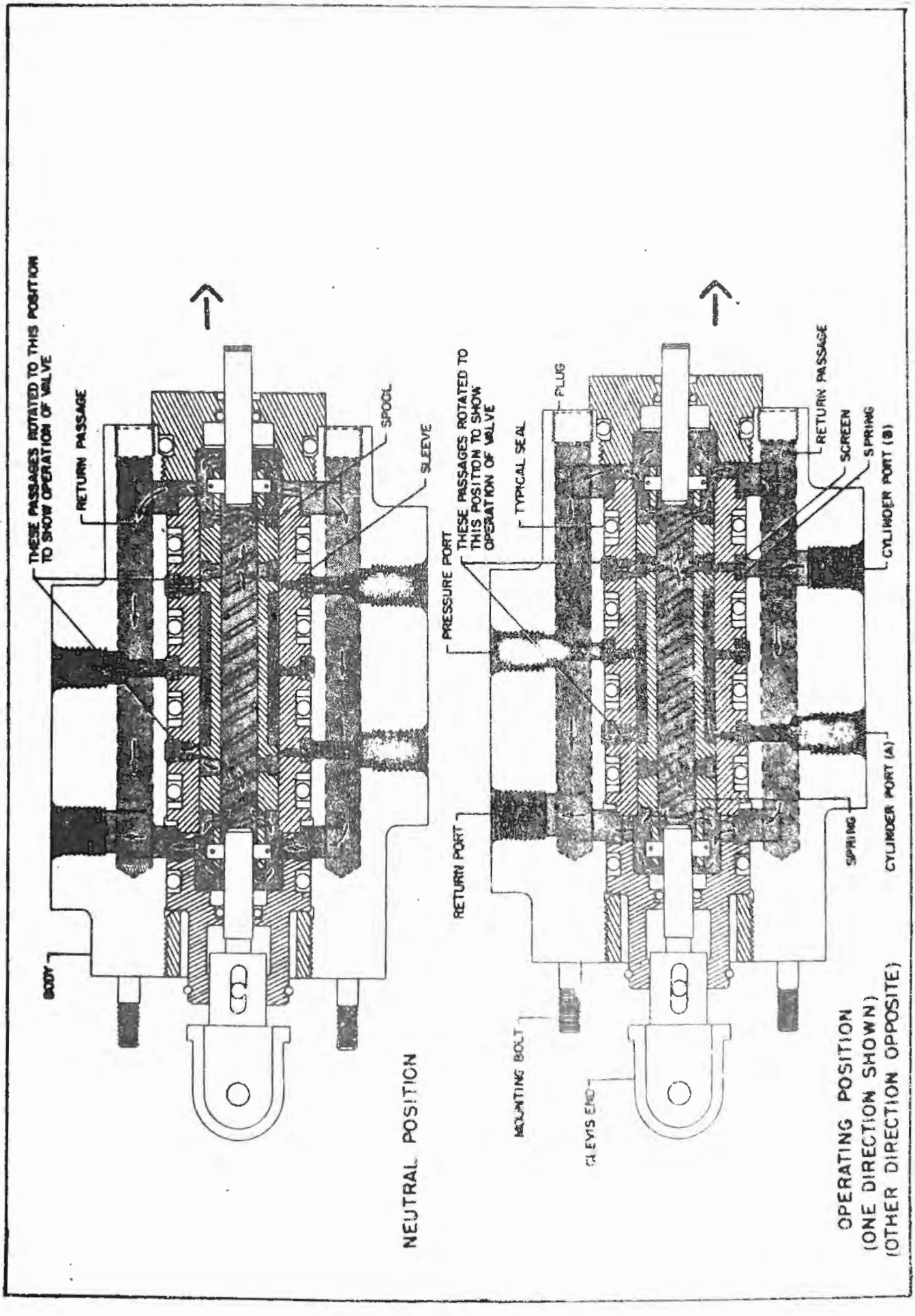


Figure 32. Aileron Power Boost System Control Valve Operational Schematic

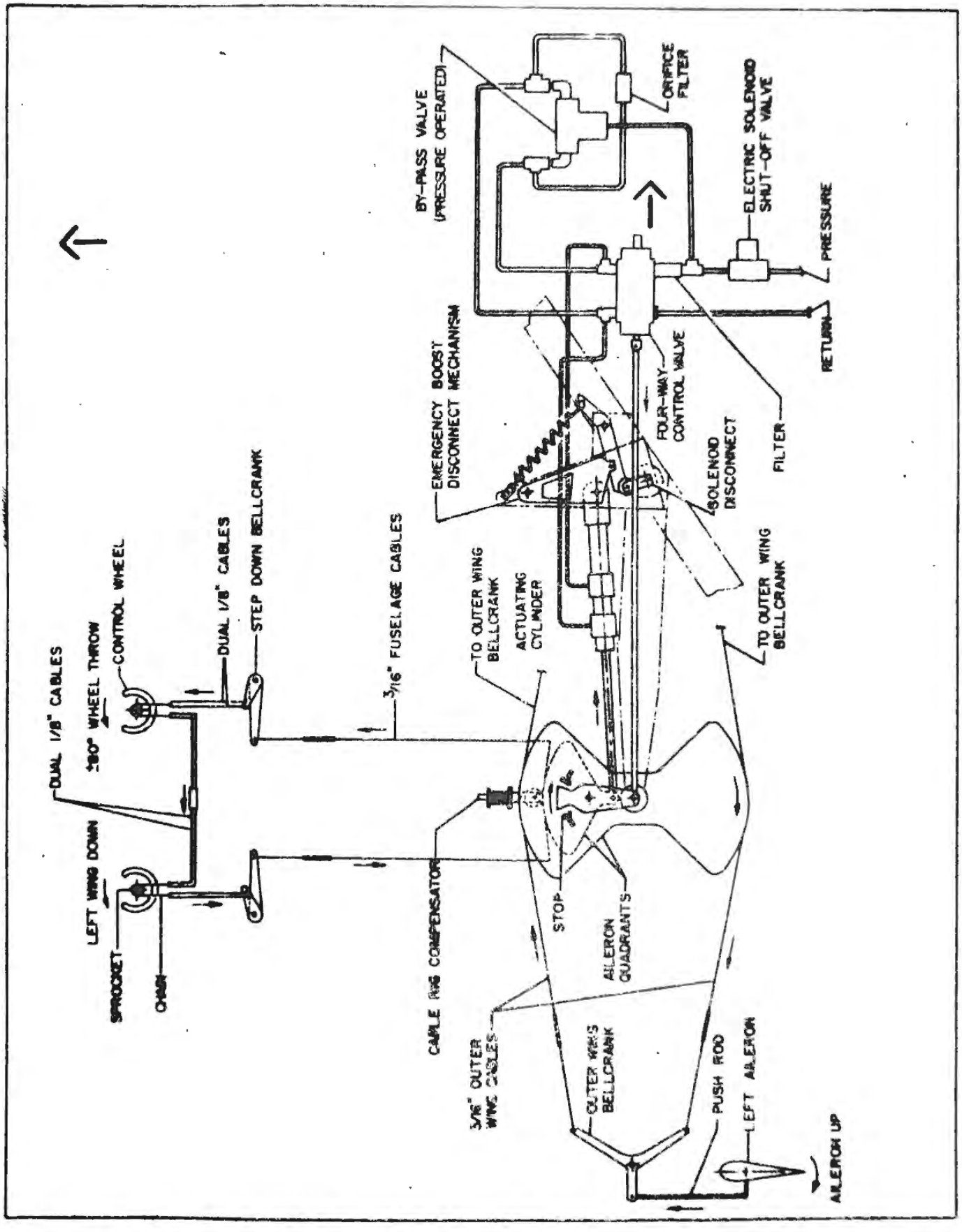


Figure 33. Aileron Power Boost System Schematic

FUEL SYSTEM - GENERAL.

The fuel system of the 404 airplane consist of six interconnected flexible Mareng cells in each outer wing; a Cross-Feed Fuel System; Primer System; Oil Dilution System; Carburetor Vapor Return System; Cabin Heater Fuel System; Anti-Icing Heater Fuel System; Fuel System Electrical Circuits, and Fuel Quantity Pressure, and Warning Indicating Systems.

Operation Of Fuel System (See figure 17).

Each engine has essentially an independent fuel system, with a cable controlled selector valve in each nacelle to select the fuel distribution. The fuel selector control handles are located on the pedestal in the pilots' compartment. A Cross-Feed Fuel System connects the right and left selector valves, permitting fuel from the right or left fuel tank to be routed to either engine as desired. Fuel is supplied under pressure to each unit from its respective fuel tank by an electrically operated submerged booster pump, located in the aft inboard cell, and the engine-driven fuel pump, located on the aft engine accessory caseing. The fuel cells are pressure-filled through a bottom filler valve under each wing. The cells may also be filled by gravity-flow through a top filler opening in each outer wing.

A complete set of aircraft fuel controls for each engine are provided in the pilots' compartment. Separate controls are provided for the Oil Dilution, Cabin Heating, and Anti-Icing Fuel Systems, each of which is supplied from the main fuel system. Fuel Pressure Transmitters, and Warning Indicators are provided for warning when fuel pressure drops to a low value.

For normal operation fuel is routed through the following units, submerged booster pump, Main Fuel Line Check Valve, Selector V lve, Main Fuel System Strainer, Fire Wall Shut-Off Valve, Engine Driven Fuel Pump, Fuel Flow Transmitter, and Carburetor, where the fuel is metered to the engine.

CROSS-FEED FUEL SYSTEM-GENERAL (See figure 15).

A cross-feed fuel system is provided to supply the right or left engine with fuel from either fuel tank. Fuel selection controls are located on the forward top side of the pilots' pedestal.

Cross-Feed Fuel System Operation (See figure 15).

A cross-feed fuel system is incorporated between the two independent fuel systems, and is connected by the right and left selector valves. The cross-feed system is normally unpressurized due to the cross feed pressure relief valve which prevents excessive pressure increase due to fuel expansion when the selector valves are closed. Fuel may be routed to either engine, but not from tank to tank. This is due to the main fuel supply check valve in each supply line which allows fuel to flow inboard to the selector valve only. See detail B for cross-feed fuel selection control setting. For selector valve operation see index of this chapter.

Cross-Feed Fuel Pressure Relief Valve. (See figure 17).

The spring-loaded cross-feed pressure relief valve is located on the fuel tank manifold fitting in the left wing only. The valve is accessible by removing the wing splice cover plate. The valve is installed in the cross-feed line to protect the line from excessive pressure, due to temperature rise and is set to open when the pressure exceeds 30 psi allowing the fuel to by-pass to the left fuel tank.

PRIMER SYSTEM - GENERAL (See figure 9).

The purpose of the primer system is to supply priming, to the engine during starting operation. The priming system consists of the following components: a momentary "ON-OFF" toggle switch, engine selector switch, primer solenoid valve, circuit breakers, and electrical connections.

Primer System Operation (See figure 9).

The operation of the engine primer system is accomplished by placing the engine "SELECT" switch in either engine position and the "PRIME" and "START" switches in their respective "ON" positions. The "PRIME" and "START" switches are toggle-type, momentary "on" and must be held manually in the "ON" position. Each of the above switches is mounted on the overhead switch panel. The "SELECT" switch is held in the desired position and at the same time the "START" and "PRIME" switches are actuated.

Power from the forward distribution bus is supplied through a "STARTER" and "PRIMER" toggle-type circuit breaker, on the main circuit breaker panel, located on the aft side of the pilots' compartment bulkhead. The "PRIME" switch actuates the right or left engine primer solenoid, depending upon which position the "SELECT" switch is held. The respective engine "FUEL BOOSTER PUMP" switch located just to the left of the "START" and "PRIME" switches must be placed in the "ON" position to supply fuel during the starting and priming operation. When the "PRIME" switch is held in the "ON" position, the switch closes, thus energizing the primer solenoid, located on the aft section of the carburetor and unseating the needle valve. Priming is internal through a line from the primer valve to the carburetor adapter. Refer to Chapter 11 for further information.

Oil Dilution System (See figure 17).

The fuel supply for the oil dilution system is taken from the main fuel line strainer, located on the left side of each nacelle within the wheel well. The oil dilution line leads aft from the strainer to a tee fitting then passes forward through a manual shut-off valve and a restrictor fitting, located just aft of the shut-off valve. From this point the line leads overhead to a sequence valve, located on the top of the oil tank. For further detail refer to Chapter 13.

Carburetor Vapor Return System (See figure 17).

A carburetor vapor return line, attached to the right aft section of the carburetor casing, leads aft through the firewall into the wheel-well and outboard to the forward inboard fuel cell. A check valve is located at the vapor return line attachment point to the fuel cell. This valve is to prevent the back flow of fuel.

Cabin Heater Fuel System (See figure 15).

The cabin heater fuel supply originates at the carburetor of each engine through a restrictor fitting, attached to the lower aft section of the carburetor casing, and passes to the aft left side of each engine accessory section to the cabin heater solenoid valve, located just aft of the main engine firewall. This valve controls the flow of fuel from the carburetor to the cabin heater fuel fume tight box, located in the fuselage belly and accessible through the cabin heater access hatch. For further information see Chapter 17.

Anti-Icing Heater Fuel System (See figure 15).

There are two anti-icing heater supply lines from the main fuel system leading to the anti-icing heater fuel fume tight box. The anti-icing heater fuel supply originates at the main fuel system strainer, located on the left side of the wheel well. The heater fuel line from the strainer passes aft to a master solenoid valve, located just aft of the strainer. This solenoid valve during normal operation of the anti-icing heaters controls the flow of fuel to the heater fuel fume tight box, located on the aft side of the front spar in the nacelle. An auxiliary fuel supply line is tapped into the main fuel system cross feed line just inboard of main fuel selector valve, located in wheel well on the forward side of the front spar. The heater fuel line passes up to a solenoid valve and aft through the bulkhead to the anti-icing heater fuel fume tight box. For further fuel control and anti-icing heater operation see Chapter 18.

FUEL TANKS (See figure 17).

Each of the two main fuel tanks located in the right and left outer wings respectively are made up of six interconnected, flexible Mareng cells. The usable fuel capacity of each tank is 675 gallons, with an expansion space of ± 2½% per tank. The cells are separated fore and aft by a tank beam, and inboard and outboard by wing ribs. The cells are made slightly larger than the compartment to prevent strain on the cell material when filled. The cells are not identical in size and shape but are designed to fit their respective compartments, and are interchangeable from plane to plane. Access doors are provided for each cell and are located on the under surface of the wing. The cells of each fuel tank are connected by interconnector fittings which allow the passage of air and fuel from cell to cell. A typical spider and spool type interconnector fitting as shown in detail A, is used to connect all cells, with one exception. The flapper type interconnector (detail B) is used in the lower inboard section between the forward and aft inboard cells. Should the fuel supply become low during flight operation, the flapper type interconnector will trap the fuel in the aft inboard cell where the booster pump is located, and prevents the fuel from passing into the forward inboard cell during landing operation, thus making the entire fuel supply usable. The spools are installed in the wing rib web and tank beam. The spiders, one on each side of the spool, are installed from inside the cells against the cell wall which acts as a gasket between the spool and the spider. A bolt secures the spider to the spool, sealing the connection. A nipple type fitting replaces the spider where hose connections are made. The following components are incorporated in the fuel tanks and will be discussed in detail under separate heading; a fuel filler and defueling valve and float unit, fuel quantity drop sticks, fuel quantity transmitter units, fuel tank top filler, fuel tank vent system, submerged fuel booster pump.

Fueling And Defueling Valve And Float Unit. (See figure 1).

The fueling and defueling valve is mounted in the aft inboard cell of each tank and is accessible through the aft inboard cell access door #11, located just outboard of the nacelle on the under surface of the outer wing. This valve consists of a housing, a spring-loaded inlet piston, four flapper-type check valves, and a safety cap covering the hose connection fitting.

When the fueling hose nozzle is attached to the filler valve for fueling operations, a lever attachment on the hose connection is manually forced down which, in turn, opens the inlet piston of the valve, thereby allowing fuel to enter the housing unit of the valve. The flapper-type valve outlets are held in a closed position during fueling operation by fuel pressure. The pressure of the fuel entering the lower housing unit, forces the outlet piston upward which opens the outlet in the upper housing unit allowing the fuel to pass into

Fueling And Defueling Valve And Float Unit (Cont.).

the cells. At the same time a bleeder hole in the outlet piston allows some of the fuel to flow up through the piston shaft to a small fuel line routed aft to the flap cove and outboard along the rear spar to the airleron cove. A fitting permits the line to pass forward through the rear spar into the tank and to the float unit which is attached to the surge relief valve located in the aft inboard cell.

The float unit consist of a float, and a float-operated needle valve. The fuel flows out through the needle valve when the float is in a down position. When the fuel level rises, the float unit rises closing the needle valve and causing a differential back pressure against the top side of the outlet piston which along with the spring forces the outlet piston to a closed position cutting off the flow of fuel into the cells. The float units, although attached to the surge relief valve has no bearing on the operation of this valve.

During defueling operation the attachment of the defueling hose nozzle and the lever operation of defueling nozzle will force the inlet piston upward, allowing fuel within the cell to pass through the lower housing check valve and the inlet piston opening to the defueling hose.

CAUTION

When defueling the tanks the top filler cap (see figure 3) should be removed to prevent the possibility of collapsing the fuel cells

Fuel Surge Relief Valve (See figure 1).

The surge relief valve is a safety device used to prevent excessive pressures in the tank during under wing fueling operations. This valve is located on the underside of each wing at station 430. It utilizes the tank pressure for its operation. If the pressure builds up above 2 ± .5 psi, a poppet in the surge relief valve is forced down, operating an actuating stem which opens a small disc in the bottom of the wing and relieves the pressure. The poppet will reset when the disc is closed. A hook is provided on the valve disc to open and close the valve manually. Approximately 15 pound force on the hook is required to pull the disc down

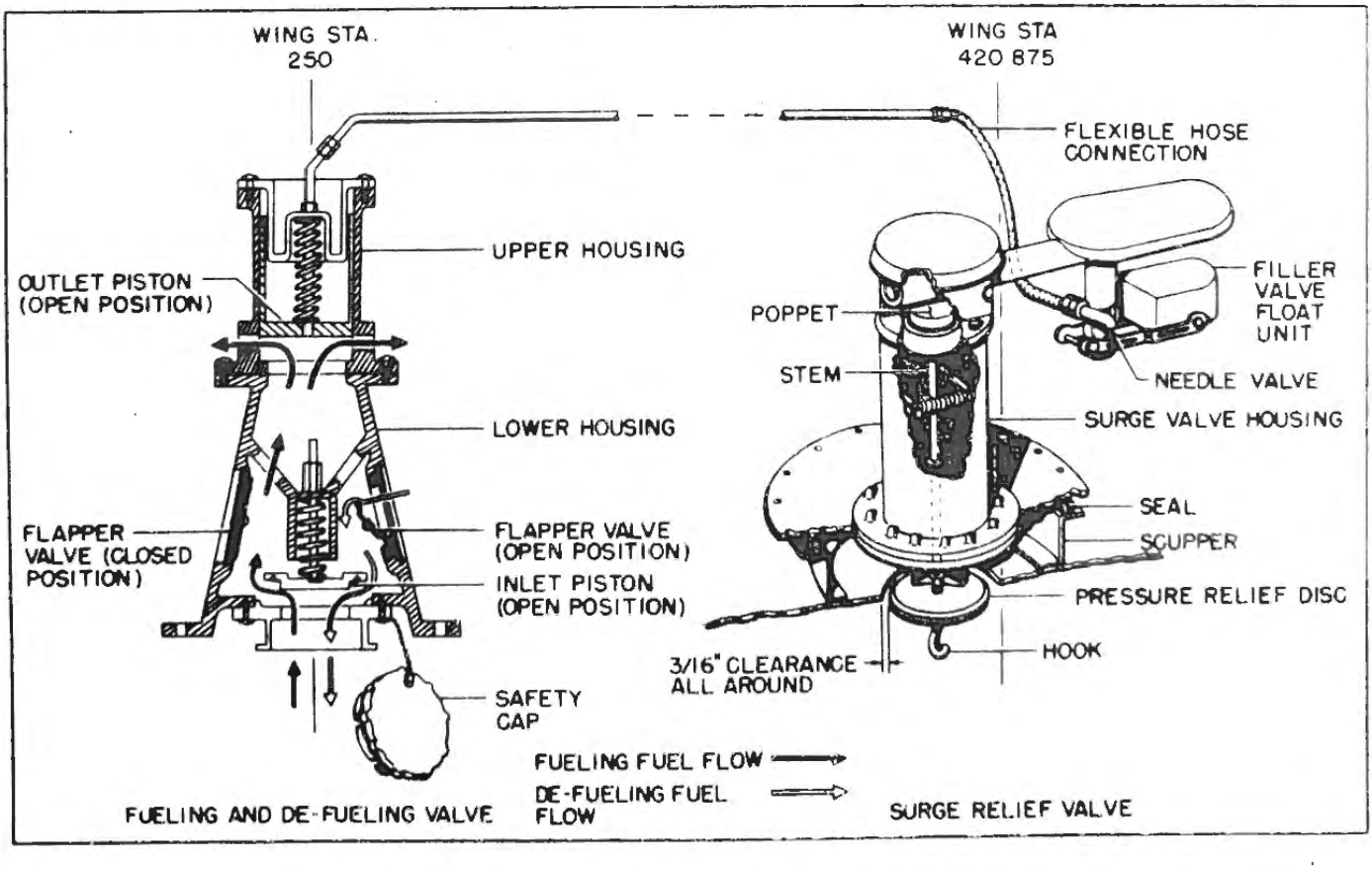


Figure 1. Fueling And Defueling Valve And Float Unit

Fuel Quantity Drip Sticks (See figure 2).

There are two manually-operated drip sticks in each fuel tank. One each is attached to the aft inboard and aft center cell doors of each wing. The component parts of each consist of two tubes, one inside the other; a spring and washer assembly, a drilled threaded cap with a lock-nut on top of the tubes, and a cap on the bottom which is drilled through the casing in four places to permit the flow or drip of fuel. The inboard drip stick is graduated from 30 to 300 gallons, and the outboard drip stick from 300 to 500 gallons. No reading can be obtained above 500 gallons by the drip stick method. The drip stick screws into the tube assembly and is locked in place by means of the ratchet and serrations on the bottom cap.

When the bottom cap is unscrewed and the drip stick pulled down slowly, fuel will drip out the holes in the cap. This indicates that the top of the stick is at the fuel level and the fuel is flowing through the hole in the top cap, down through the tube, and out the holes in the bottom cap. The quantity markings on the tube will be visible to read when held in this position. If fuel drips when the stick is first unscrewed it may indicate that fuel has been trapped in the tubes. If so, the dripping should stop in a short time. However, if fuel continues to flow, it indicates that there is more than 300 gallons in the inbosrd tank or more than 500 gallons in the outboard tank.

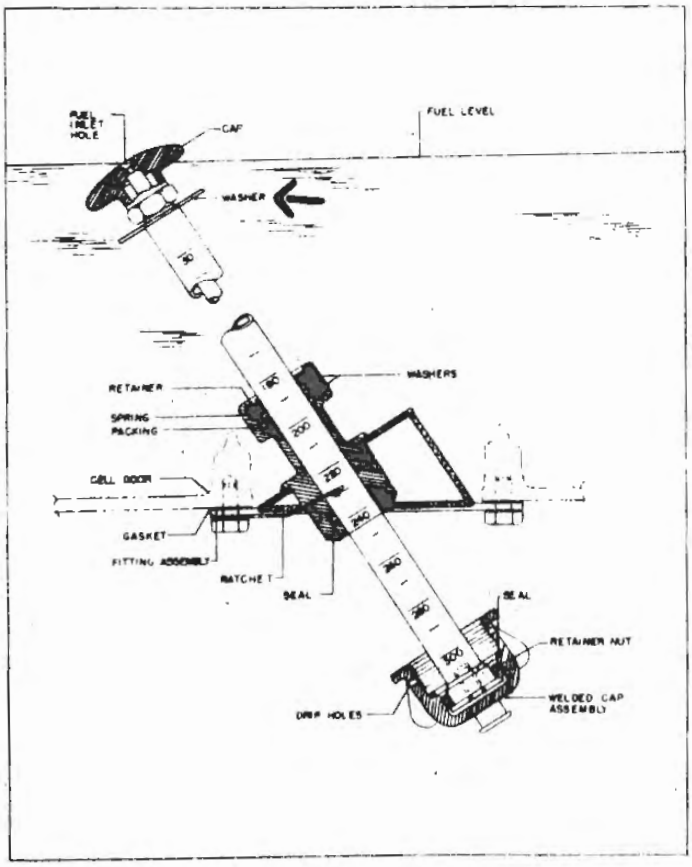


Figure 2. Fuel Tank Drip Stick (Inboard)

Fuel Tank Drain Valves (See figure 7).

Two drain valves are incorporated in each fuel tank to permit draining of accumulated water, and sediment from the tanks and fuel line. One of these valves is located on each booster pump plate assembly, and is accessible through the booster pump access door #12. Another drain valve is incorporated in each main fuel strainer drain line (See figure 17) and is accessible through the main wheel well.

Fuel Tank Vent System (See figure 17 A).

The purpose of the fuel tank vent system is to provide an escape for air within the cells during the fueling operation, and to allow displacement of the fuel being used by air during flight and ground operations, thus aiding in preventing the collapsing of the cells when the fuel reaches a low level. A flap er-type relief and check valve, actuated by a float unit, are attached to the top outboard section of the aft outboard cell. The vent line extends from the valve forward to a Wickerbill vent located on the under surface of the wing at station 455. During the fueling operation, the displacement of the air by fuel within the cells forces the air out the vent relief valve, and overboard through the Wickerbill vent. However, when the pressure within the cells reach 2.5 psi the poppet in the surge relief valve is forced down releasing any excessive pressure. The float which normally is in a down position holding the relief valve open and allowing the escape of air from the cells will, when forced upward by the rising of the fuel within the cell, close the valve and prevent fuel from running overboard through the vent.

An auxiliary vent line is attached to the Wickerbill vent line by a tee fitting. If the Wickerbill vent is iced-up this permits air to be taken from the aileron cove and passed through a check valve into the fuel tank to maintain atmospheric pressure in the tank as the fuel is used. The spring-loaded check valve is incorporated in the line to prevent ram air pressure from passing in the Wickerbill vent and out the opening in the aileron cove during normal operation.

Fuel Tank Top Filler (See Figure 3).

A top filler is provided for each wing fuel tank and is located under the access door on the top surface of each wing at approximately wing station 400. The top filler consists of a removable screen, filler cap, scupper, scupper drain for over-flowing fuel, and tubing routed to the under surface of the wing. The top filler permits gravity filling of each fuel tank and serves as a standby for the underwing fuel filler.

MAIN FUEL LINE CHECK VALVE (See figure 15).

A main fuel line check valve is provided in each main fuel line and is located just outboard of each nacelle between the booster pump and the fuel selector valve. This is a swing-type valve and its purpose is to prevent careless transfer of fuel from one tank to another, which could cause an unbalanced condition in the airplane.

FUEL SELECTOR VALVE (See figure 17B).

A fuel selector valve is mounted on the forward side of the front spar at wing station 150 of each wing. The valve is accessible from the wheel well and is interchangeable from left to right. Each valve is operated by a two-way cable system, running to a control lever on the pilots' pedestal. The selector valve can be disconnected at the yoke and removed without disconnecting the control mechanism. The valve has three external ports and four internal ports, and can be set in five possible positions as indicated on the name-plate under the selector handle. It is permissible for the handle to have ½ inch deviation to either side of the center mark of each segment. Through various combinations of the two valves, it is possible to control the flow of fuel completely under all conditions at all times.

The flow of fuel from a tank is shut-off by placing the fuel selector for that tank in the "OFF" position (see figure 15).

The flow of fuel is directed from a tank to its respective engine by placing the fuel selector in "NORMAL-TANK-TO-ENG." position. (see figure 15).

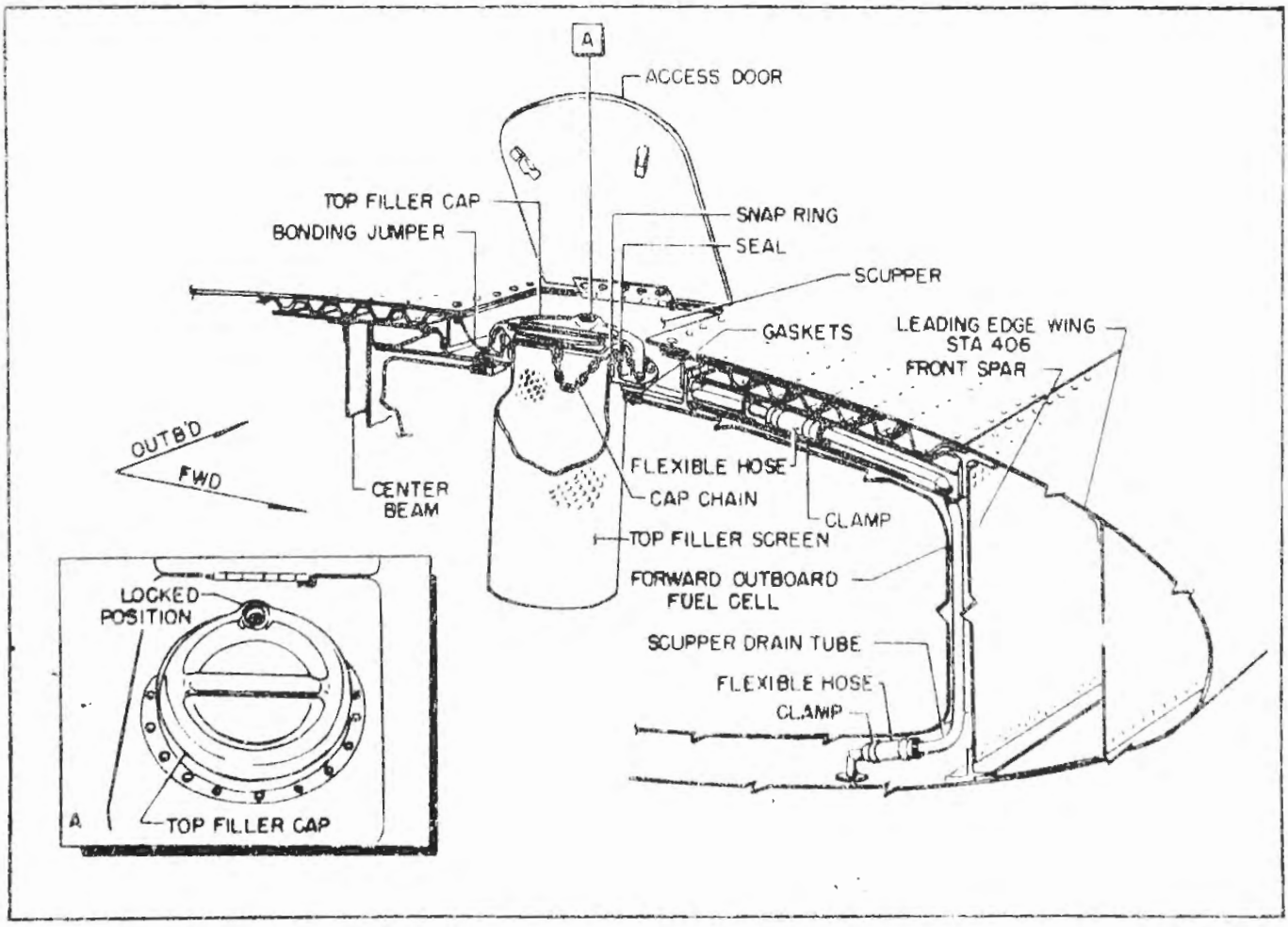


Figure 3. Fuel Tank Top Filler

FUEL SELECTOR VALVE (See Figure 17B). (CONT.)

The flow of fuel is directed to both engines from one tank by placing one fuel selector in the "TANK-TO-ENG. AND CROSS-FEED" position and the other fuel selector in the "CROSS-FEED-TO-ENG." position.

The flow of fuel is directed to only one engine from the opposite tank by placing one fuel selector in the "TANK-TO-CROSS-FEED" position and the other fuel selector in the "CROSS-FEED-TO-ENG." position.

WARNING

Placing both fuel selectors in the "TANK-TO-CROSS-FEED" or "CROSS-FEED-TO-ENG." position will stop the flow of fuel to both engines.

FIREWALL SHUT-OFF VALVE (See figure 17).

The firewall shut-off valve is mounted on the aft left hand side of the firewall in each nacelle and is accessible through the main gear wheel well. The main fuel line passes forward from the main fuel strainer into the center outlet fitting of the firewall shut-off valve and continues forward to the engine driven fuel pump. Refer to Chapter 19 for details of firewall shut-off valve.

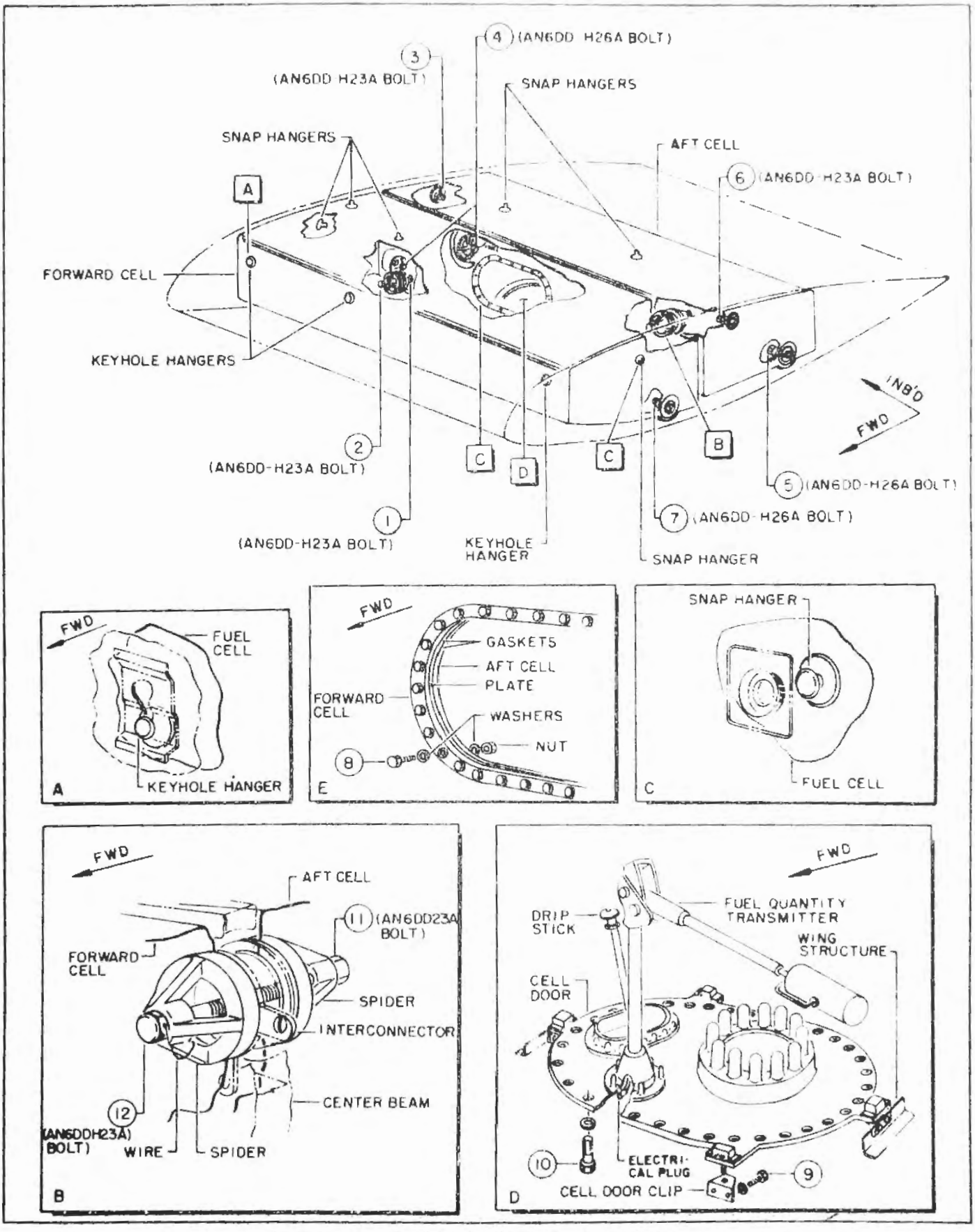


Figure 21. Center Fuel Cells Installed

1 - Fuel Service 300 gals Per Min.
2 - Pull down Surge Valve.
3 - Defuel 100 gals Per Min
4 - Use Low Booster Pump above 16,000'

E. ILLUSTRATION OF FUEL SYSTEM

FUEL QUANTITY INDICATING SYSTEM (See figure 13).

The fuel quantity indicating systems consist of one dual-reading quantity indicator, which is mounted on the engine instrument panel, and one quantity transmitter located in each of the aft three cells of each wing tank. Two repeater indicators are provided, one each for the right and left wing tanks. The repeater indicators are mounted on the outboard side of each nacelle. The right and left tank fuel quantity systems are separate systems utilizing a single dual-reading indicator. The liquid totalizing sequence of each system registers the quantity of fuel on a dual quantity indicator, which is mounted on the instrument panel in the pilots' compartment, and on its respective repeater indicator, located on the aft outboard side of each nacelle.

During the fueling operation, the float unit, attached to each transmitter will rise from the bottom position to the top position as the fuel enters the cells. The rising of the fuel level, acting on the float arm within the cells, reflects an increasing fluid level on the indicators.

Fuel Quantity Transmitters And Float Units. (See figure 13).

The three fuel quantity transmitters of each fuel system are float and potentiometer type units and are located in the aft inboard, aft center and aft outboard cells of each tank. Refer to Chapter 23 for principle of operation of these units of the float type.

FUEL QUANTITY INDICATOR (See figure 13).

The dual reading indicating element of the fuel quantity indicating system contains two units, each consisting of three coils and a polarized rotor to which a pointer is attached. A change in the fuel level acting on float unit arms within each tank shifts the resistance from one side of the circuit to the other causing a change in the magnetic field set-up in the three corresponding indicator field coils. This action will cause the pointer to move correspondingly, indicating the amount of fuel in each system.

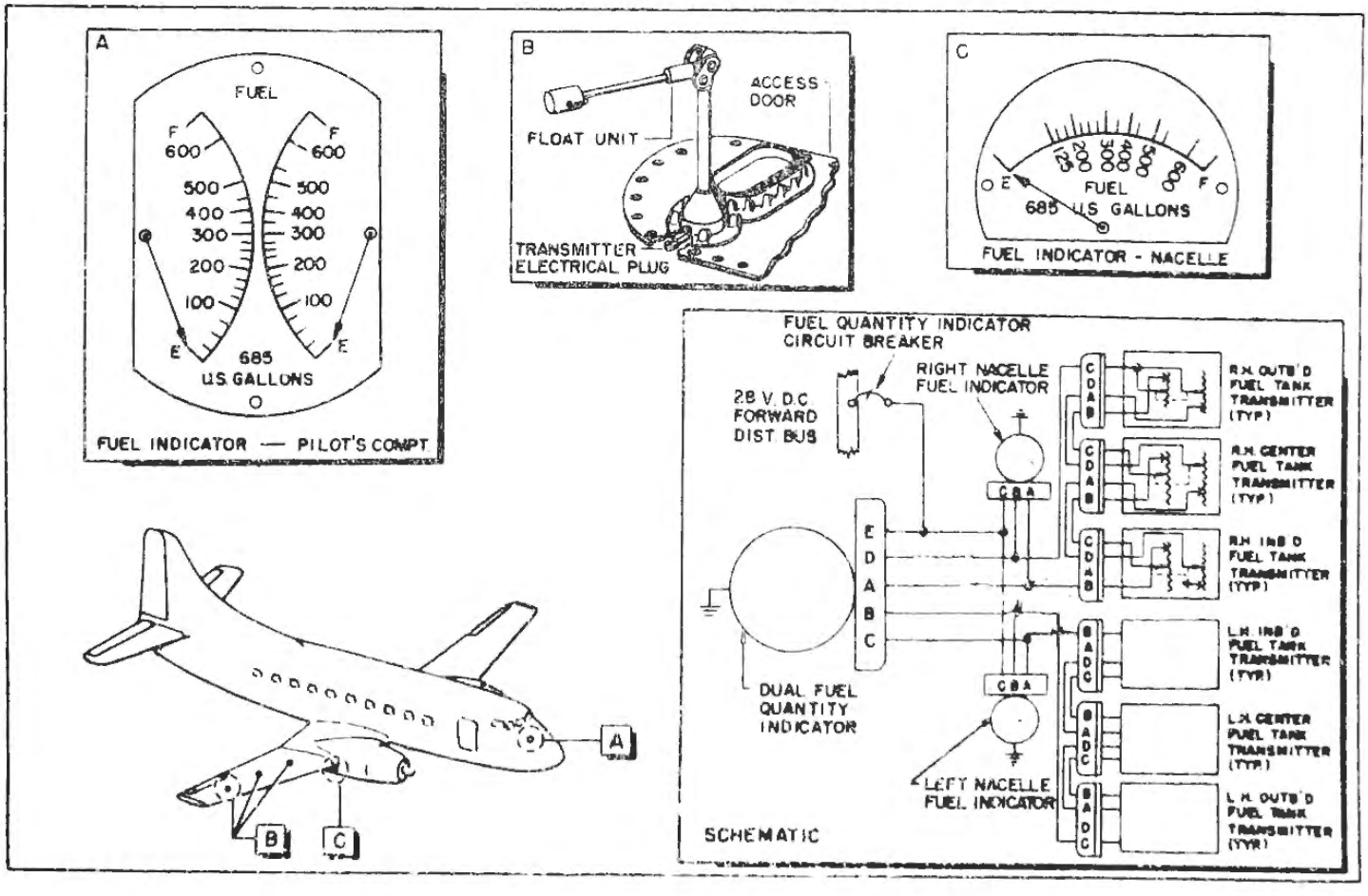


Figure 13. Fuel Quantity Indicating System Schematic

PROPELLERS - GENERAL (See Fig. 12)

The airplane is equipped with two model 43E60 Hamilton Standard, three-blade "Hydromatic" propellers incorporating a feathering action and a reverse pitch action. Fluid de-icing of the propeller blades, as explained in Chapter 18, is provided. The propellers are controlled through an electrically operated double-acting governor, which is mounted on the nose case of each engine. An electrical external contacting system is used for propeller control and reverse indication and an auxiliary pump is used to provide the high pressure oil necessary for the feathering and reversing actions.

In the event of an engine failure on take-off the propeller on the affected engine will feather automatically. In case of a failure of both engines, the left propeller will take precedence over the right and auto-feather. This action will also prevent the other propeller from auto-feathering.

To provide an ultimate in safety, the propellers can be reversed only after the weight of the airplane is on the landing gears. The normal throttles must be retarded to the closed position before the reversing levers can be actuated. Refer to Chapter 9 for throttle rigging.

The reverse solenoid wires and adjacent wires in in the electrical hatch at the reverse relay panel electrical connector are wrapped with red identification tape for a distance of approximately four inches from the connector. This is for the purpose of monitoring the future condition and handling of these wires. Any wire so identified shall not be changed without specific formal engineering authority.

The feathering pump and relays are energized directly from the feathering button and the reverse solenoid through the "A" relay contact in the unfeathering operation. With the propeller at full low pitch, pulling out the feathering button to unfeather position will result in a RPM drop necessary to drop the #1 blade switch plunger off the cam. With continued holding out on the feathering button the RPM should stabilize and the propeller should not feather or reverse.

The control circuit "E" relay, which terminates unreversing, receives its power from the normal closed contacts of the single pole throttle switch. This circuit arrangement causes the propeller to go to the feathered position, if the single pole (arming) throttle switch sticks in the mechanically actuated (reverse) position upon unreversing, since no power will be supplied to "E" relay coil under this condition. This is the same action that occurs if the No. 1 blade switch sticks in the open position, makes high resistance contact during unreversing, or the circuit is open due to broken wires or brushes. The No. 1 blade switch circuit is the most likely cause, if the propeller feathers during unreversing and should be checked for a possible open circuit; however, if the blade switch circuit is found to be functioning properly, it should be remembered that the single pole throttle switch may be stuck in the reverse position.

PROPELLER OPERATION (See Fig. 12)

The propeller operation may be broken down into constant speed operation; feather, unfeather, reverse and unreverse; Constant speed operation is described under Propeller Governor Constant Speed Operation.

(Cont. next page)

FEATHER (MANUAL) (See Figure 1).

Push the feathering button in and it will stay in because it energizes its own hold in coil. When the button is pushed in, it starts the auxiliary pump and the indicator light within the button will glow. The pump sends high pressure oil to the propeller governor. This high pressure oil flows to the positioning land and lifts it up, thus positioning the pilot valve to allow the oil to flow to the hub. This oil then acts against the propeller piston and forces the blades to the feathered position. When the blades reach full feather, it is necessary that the feathering button be pulled out manually to the neutral position to terminate the auxiliary pump action and de-energize the feathering button indicator light. The feathering action can be stopped at any time by pulling the feathering button out, allowing the governor to return to the constant speed range. The governor solenoid valve is not used during the feathering cycle.

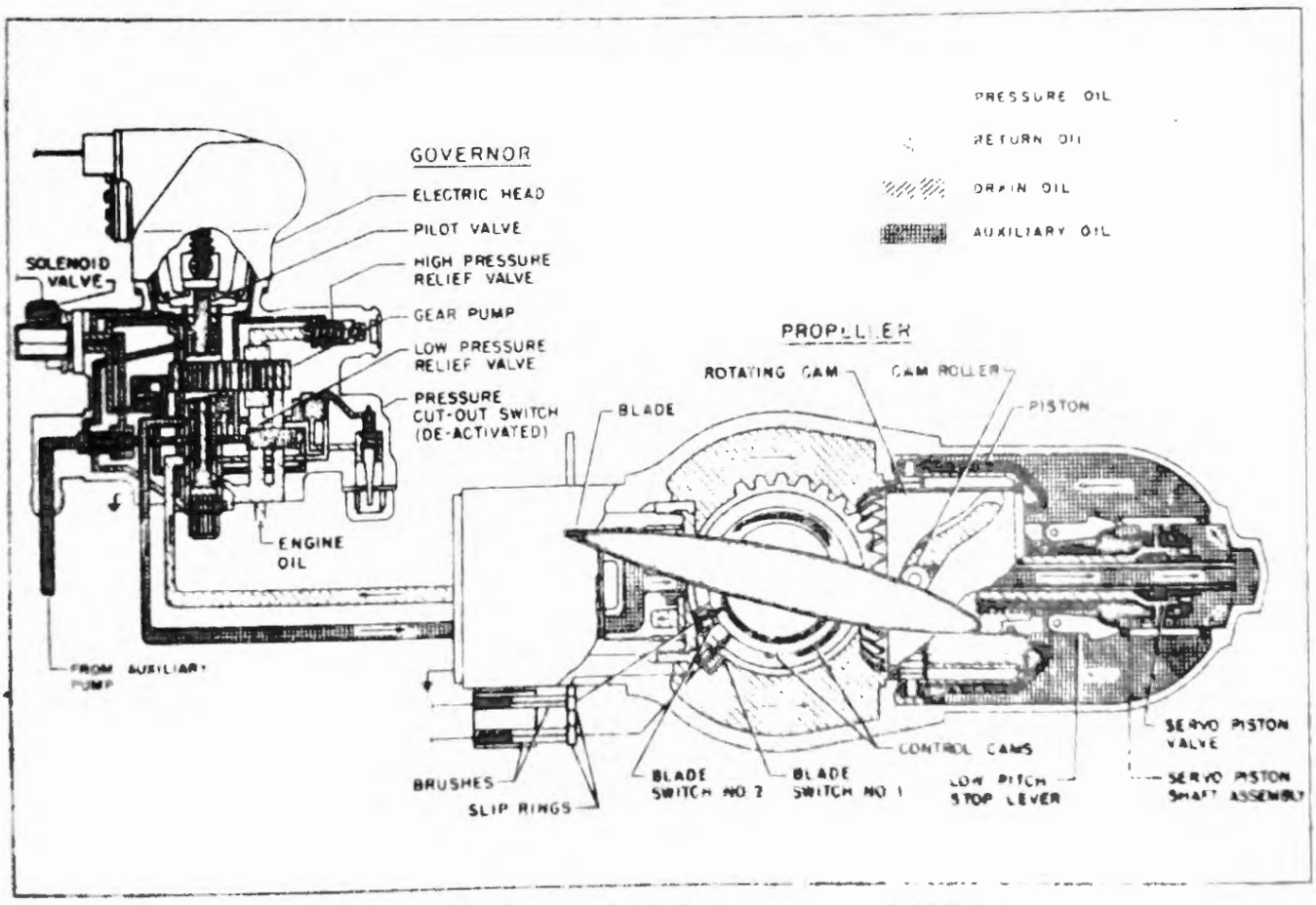


Figure 1. Propeller Feathering Hydraulic Schematic

UNFEATHER (See figure 2).

Hold the feathering button out until the engine starts to rotate, then release button. Holding the button out energizes the coil of relay "A" in the propeller relay control box and thus energizes both the governor solenoid valve and the auxiliary pump. The solenoid lifts up the governor selector valve allowing oil to push the positioning land down. This positions the pilot valve so that the oil is directed to the hub to turn the blades out of the feather position. No.1 blade switch is closed when the propeller is in feather but when the blades reach the normal pitch range, blade switch number 1 opens, breaking the ground circuit on relay "A" coil. This de-energizes the solenoid valve and auxiliary pump.

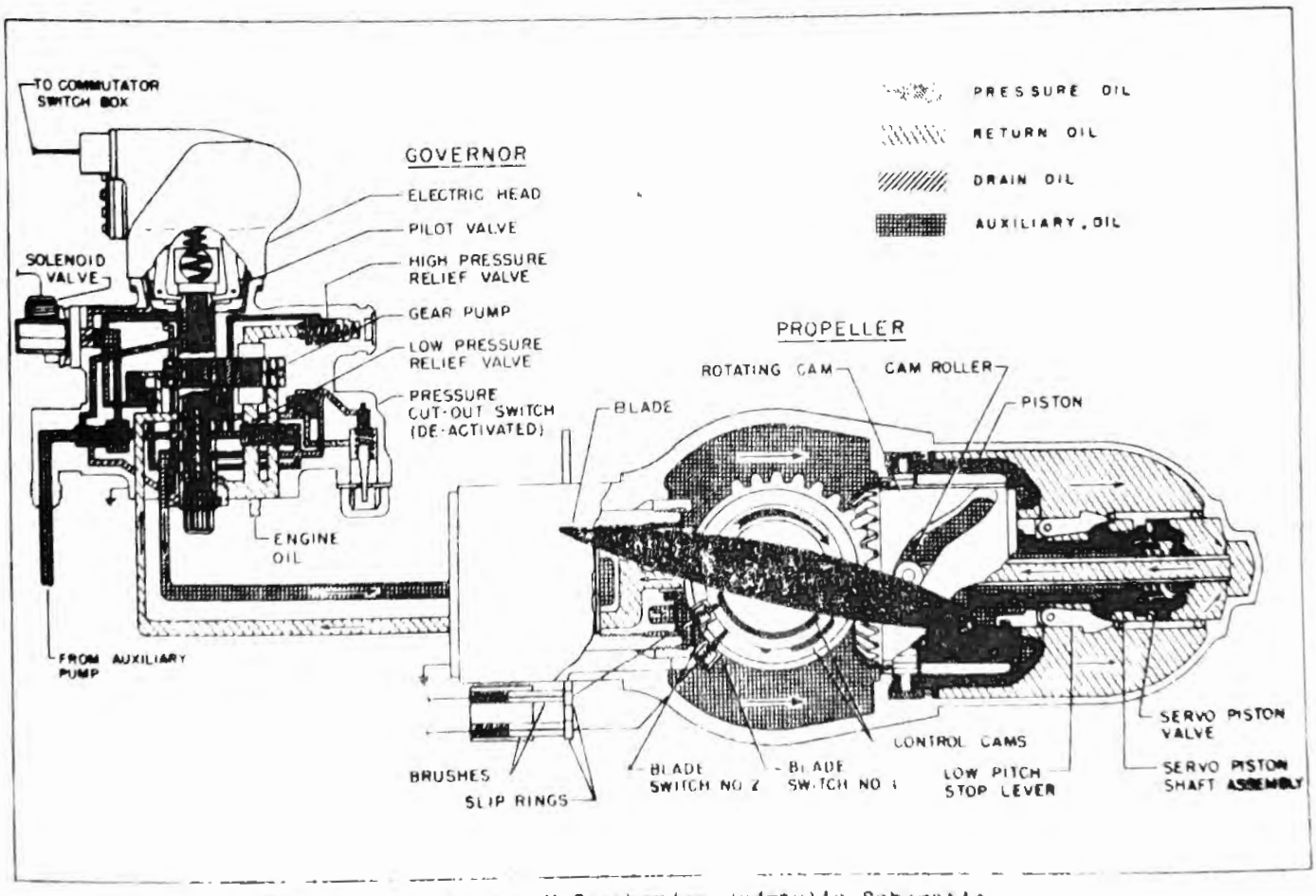


Figure 2. Propeller Unfeathering Hydraulic Schematic

Reverse (See Figure 3)

NOTE: Weight of airplane must be on landing gears except for deceleration switch action.

The reverse throttle levers pivot off the normal throttle levers and are attached to a common shaft. Retard the normal throttle levers to the idle position, then grasp the reverse throttle levers and move up and aft. This movement of the reverse throttle levers actuates the safety and double pole reversing switches. The reversing switch energizes the governor solenoid valve and also energizes "B" and "C" relays which pull in and lock in through their own contacts. Relay "B" starts the auxiliary pump, and at the same time, the governor solenoid, being energized, lifts up the selector valve allowing the high pressure oil to flow to the positioning land, pushing it down, which allows the oil to move the blades to the reverse position. The selector valve also allows the oil to flow to a valve in the governor, which blocks the governor oil pump relief valve, allowing the full output of the governor oil pump to hold the blades in the reverse pitch position. When the blades reach approximately five degrees before full reverse pitch, blade switch number two is actuated which energizes the reverse indicator light on the pedestal and also "D" relay, stopping the auxiliary pump. Mechanical low pitch stop levers in the dome assembly prevent inadvertent reversing during constant speed operation. These levers are held in position by a wedge which can only be moved by auxiliary oil pressure.

The landing gear lever lock solenoid will prevent moving the reverse throttle into reverse position when airborne. Propeller reversal is made possible immediately after touchdown, during a landing, by the function of the deceleration switches. Propeller reversal is always available when the weight of the airplane is on the gears due to the action of one or more of the three scissor switches. Refer to chapter 15 for complete description of deceleration switch and scissor switch operation.

Some airplanes are equipped with deceleration switches which de-energizes the lock solenoid immediately after touchdown regardless of the amount of weight on the landing gear.

Always unreverse the propeller after checking the reverse operation. The governor reversing is built for intermittent duty. If throttles are left in reverse the solenoid will burn out. Also a propeller left in reverse with power off, will not unreverse automatically when the engine is started. Engine operation under this condition will cause severe overheating.

For information concerning the propeller controls on the pedestal, see Figure 13. For rigging information refer to Chapter 9.

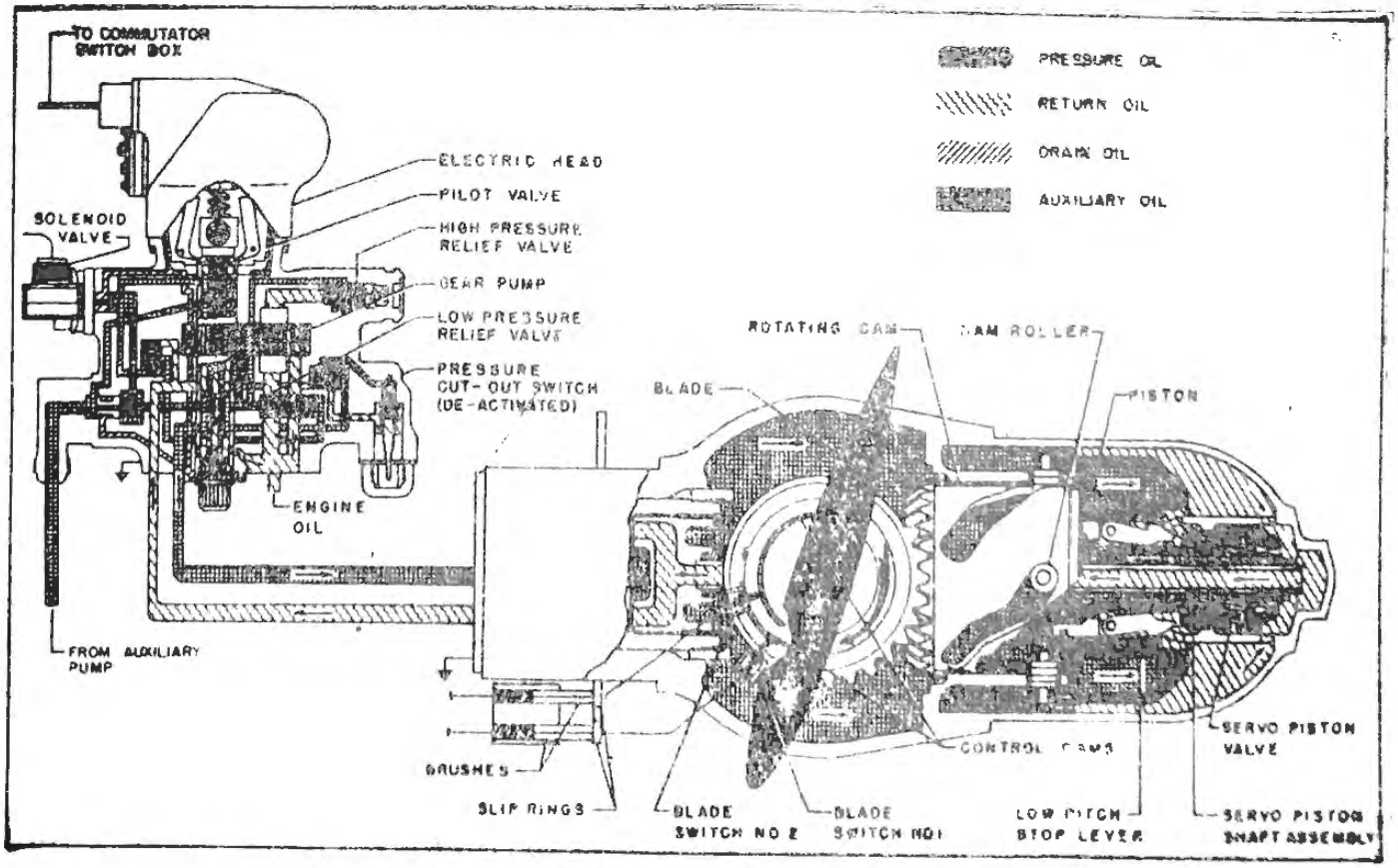


Figure 3. Propeller Reversing Hydraulic Schematic

Unreverse (See figure 4).

Move the reverse throttle levers to the idle position. This allows the safety switch and the reversing switch to return to the normal position. The reversing switch de-energizes the solenoid valve at governor and the auxiliary pump is energized through relay "B" at the same time. When the solenoid valve was de-energized, it dropped down, allowing the oil to lift the positioning land up which directs the oil to turn the blades out of reverse pitch. The reverse indicator light will go out when the blades start turning out of reverse and as the blades reach approximately one degree above the low pitch setting, blade switch number one completes a ground to the "E" relay. The "E" relay closes and de-energizes "B" and "C" relays. When "B" and "C" relays are de-energized, "C" relay opens the power circuit to the coil of "E" relay causing it to be de-energized. Thus power is removed from the complete reverse control circuit and allows the propeller to return to normal operation.

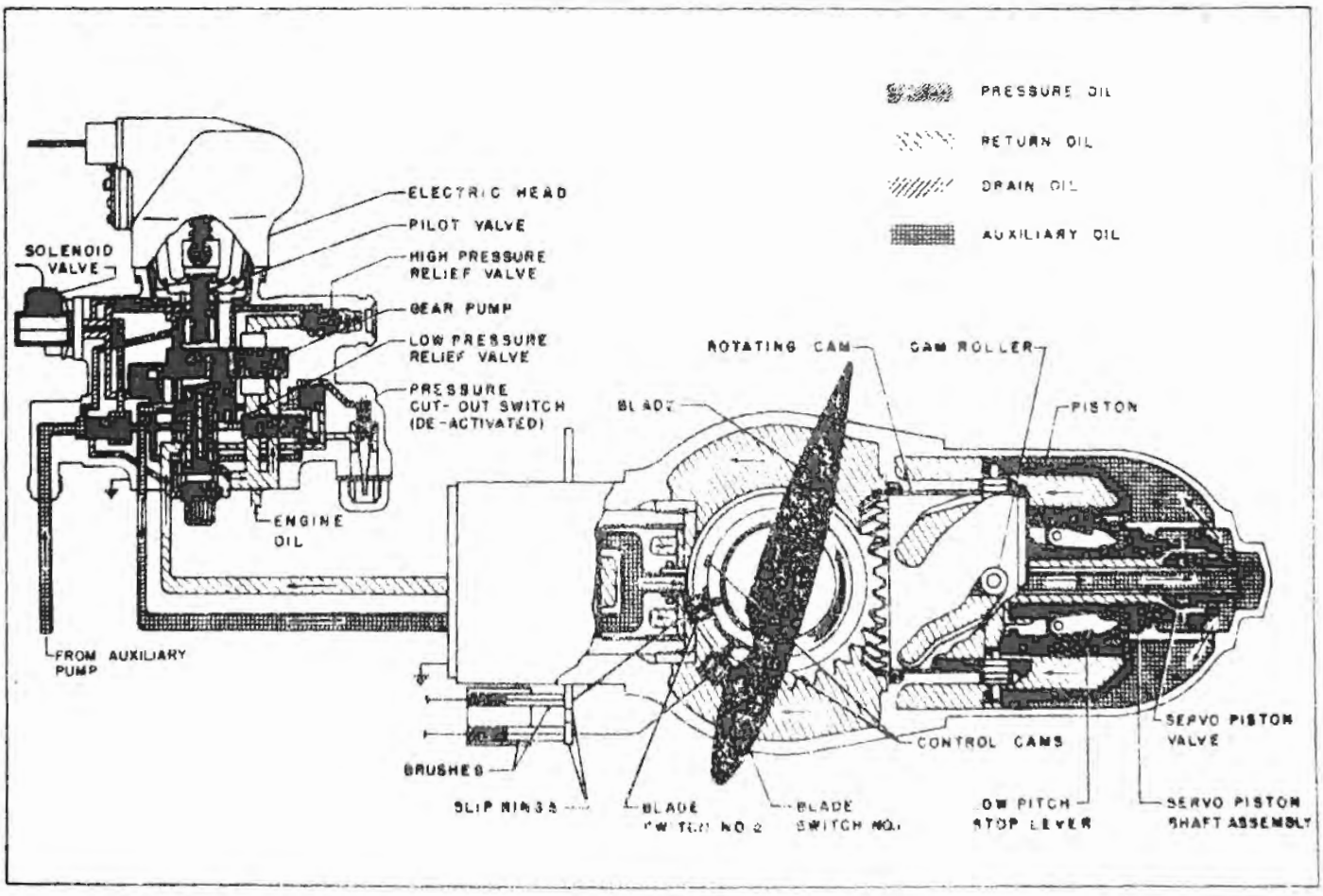


Figure 4. Propeller Unreversing Hydraulic Schematic

PROPELLER HUB AND BLADE ASSEMBLY (See figure 11).

The hub is the basic propeller mechanism in that it contains the blades and the means of holding them in position. The blades are mounted on the spider arms and retained by the shoulders at the blade bores in the barrel. Each blade is free to turn about its longitudinal axis under control of the dome assembly.

Barrel Assembly (See figure 5).

The barrel assembly consists of the two barrel halves, the spider, three barrel supports, the hub snap rings, propeller retaining nut and lock assembly, the front and rear cones, the spider and ring seal, three gear segments, three spider shim plates and shims, three blade packings, three barrel half seals, twelve barrel bolts, nuts, washers and cotter pins, and spider to shaft seal and spacer.

The barrel is manufactured in two halves which are machined and balanced as a pair and kept together throughout the service life of the propeller. The barrel carries the high centrifugal blade loads by means of shoulders at each blade bore and lips are incorporated outside the shoulders to hold the blade packings. Grooves cut into the barrel halves at the parting surface provide for barrel half seals. The outboard barrel half incorporates a shelf just inboard of the dome retaining nut threads to locate and support the dome assembly and three holes for the fixed cam locating dowels. The barrel halves are held together by nuts and bolts. The centers of these bolts are drilled out to provide for the lead wool used in final balance of the propeller. Each bolt is closed by a welch plug. Each bolt is numbered and a corresponding number is stamped on the bolt bosses in each barrel half.

The spider, considered the foundation for the entire propeller, is splined to fit the propeller shaft. The cone seats are located at each end of the central bore. The splines and the cones transmit engine torque to the propeller. The spider arms extend into the blades and in addition to supporting the blades, take the greater part of the blade thrust and torque loads. A groove just outboard of the location of the propeller retaining nut is provided for the hub snap ring. As the propeller retaining nut is backed off during propeller removal, the nut advances along the propeller shaft threads until it contacts the snap ring and thereby moves the entire hub off the rear cone.

A blade gear segment is attached in the butt of each blade by means of serrations on the inner diameter which mate with similar teeth on the outer diameter of the blade bushing. The gear teeth of the segments mesh with those of the rotating cam in the dome. The blade assembly is made oil tight within the barrel by synthetic rubber packings which fit between the outer blade thrust washer and blade packing lip of the barrel.

The propeller retaining nut has a flange on its inboard end to butt up against the front cone. It is locked to the propeller shaft by a lock assembly which projects through a hole in the propeller shaft and into a slot in the nut. The barrel support seats on the spider are numbered beginning with number 1 at the clockwise side of the spider arm number 1 looking at the outboard end of the spider, and continuing in an anti-clockwise direction; that is, in a three way spider. Number 1 barrel seat lies between arms number 3 and 1; number 2 barrel seat is between arms numbered 2 and 3. These numbers are stamped on the flat surface at the outboard end of the spider

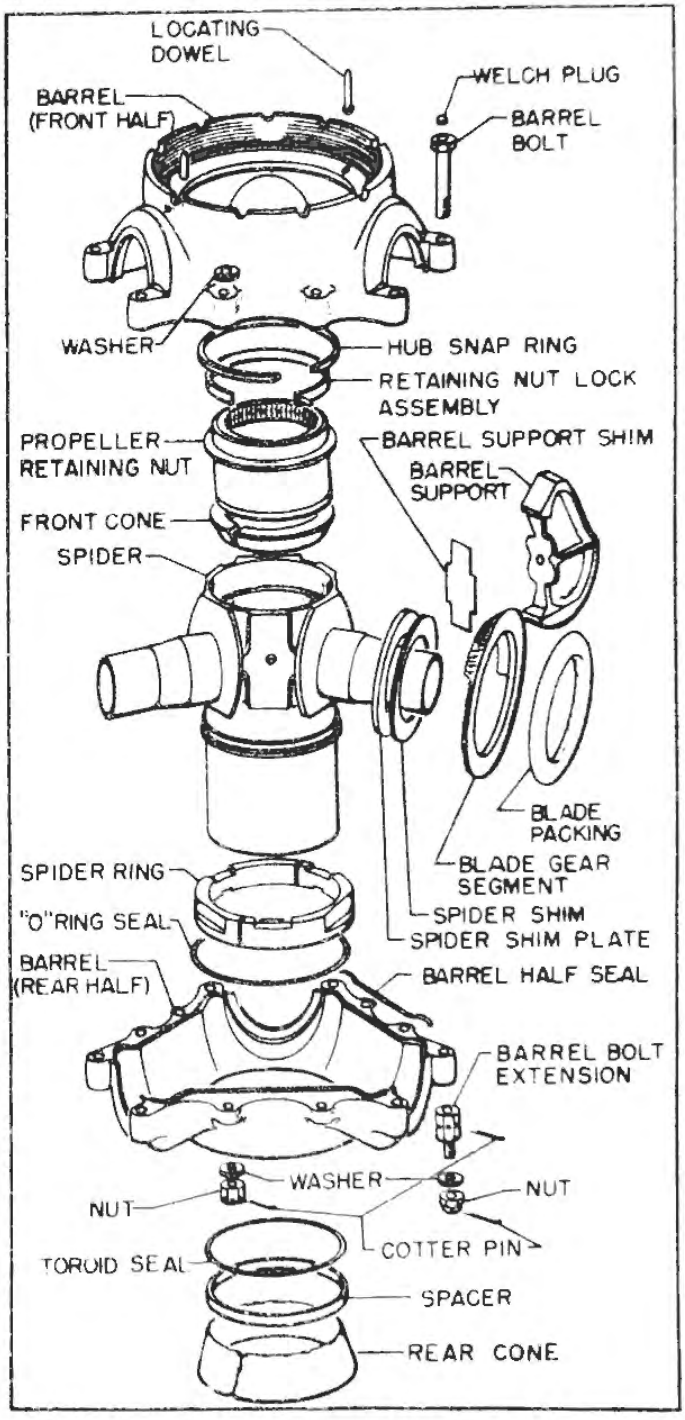


Figure 5. Propeller Barrel Assembly

Barrel Assembly (Cont.).

adjacent to the barrel support seats. The support blocks are steel stencil stamped with a position number on the beveled outboard surface.

Blade Assembly.

The blade is forged from a hard aluminum alloy and anodized. The butt end incorporates a shoulder which mates against a beveled thrust washer. To lighten the blade and to provide for the blade bushing, a portion of the shank section of the blade is forged hollow and bored to size. The blades have a cold rolled area at the shank and an intermediate shot-blasted area in the airfoil section. Fluid de-icing boots are cemented to the blades. Each blade is numbered 1, 2, or 3. This number is stamped on the blade segment. Matching numbers are stamped on the blade support blocks and the hub blade arms. Index markings are provided on the blade butt. Blade cams, for the operation of the blade switches, are attached to the shank of the number 1 and number 2 blades.

The blades have a cold-worked area which consists of a cold-rolled surface extending from the fillet to a point just outboard of the barrel and a shot-blasted area extending from a point slightly overlapping the cold rolled area to a point approximately midway on the blade. When removing damage in the shot-blasted area, it is necessary to peen the reworked areas unless three shot impressions per square inch still remain after the final polishing. Any damage in the cold-rolled area has to be repaired in the overhaul shop. Blades evidencing abrasion that has penetrated the de-icer boot may be repaired under the conditions and procedures outlined in "Blade Inspection And Service" in this chapter. See chapter 18 for "Maintenance Of Propeller De-Icer Boots". Blades exhibiting abrasions resulting from impact with a large and solid mass such as snow banks, maintenance stands, birds in flight, and so forth, should be removed from the aircraft and sent to an overhaul shop.

Minor repairs may be made to the blade surfaces within definite limits. A special technique is required for this servicing. Refer to Blade Inspection And Service.

PROPELLER DOME ASSEMBLY (See figure).

The dome incorporates the blade operating mechanism. The main operating units consist of a rotating cam and gear, stationary cam, main piston, and stop lever assembly. The low pitch stop lever assembly incorporates low pitch stop levers, a servo piston, a servo valve and oil transfer tube. The stop lever assembly is adjusted so that the main piston contacts the stop levers at the low pitch pressure to be applied to the aft side of the servo piston during reversing operations. The servo piston actuates at 240 to 250 psi and moves a wedge from under the stop levers. This permits the levers to drop and the main piston to move forward into reverse position. The servo piston and the servo valve return to closed position, due to spring loading, after the main piston sleeve has passed over the stop levers in reversing. The oil transfer tube serves as the main oil passage to and from the forward side of the piston.

A reverse dump valve (sleeve) is connected to the propeller piston and moves with it. The forward end of the valve contacts the low pitch stop levers in constant speed operation. Slots on the aft end of the valve relieve reverse oil pressure from the aft to the forward side of the main piston after reversing is complete. The stop lever assembly is the low pitch stop which is adjusted and installed in the dome at the factory or at time of overhaul.

Low Pitch Stop Lever Assembly (See figure 11).

A combination of the low pitch stop lever assembly and the oil transfer housing direct the flow of oil within the propeller. Low pitch position is maintained by mechanical stop levers attached to the lever sleeve. These levers contact the outboard end of the piston sleeve to limit piston travel at low pitch. To permit movement beyond the low pitch setting toward reverse pitch, the levers are released by the application of oil raised to high pressure, acting on a piston in the lever assembly. A lever sleeve end cap with an adjustable sleeve is included. Two bronze oil seal rings on the sleeve uncover ports in the piston sleeve at the end of reversing to relieve high barrel pressure to the outboard side of the piston.

The stop lever assembly is screwed into the lever sleeve bushing attached to the dome shell and may be installed and removed with the dome assembly. The oil transfer tube fits through the center of the stop lever assembly and forms a passage from the center of the oil transfer housing to the outboard end of the dome.

CAUTION

No attempt should normally be made to remove or adjust the stop lever assembly during service. It will be necessary, however, to remove it for cleaning for re-use after an engine failure during service.

Oil Transfer Housing (See figure 11).

The transfer housing screws into the engine shaft against a shaft gasket. The housing provides the connecting passages between the two engine shaft oil passages from the governor and the propeller dome assembly.

Stop Ring System (Feather And Reverse Stops) (See figure 15).

The stop rings are installed on the aft end of the dome and a stop ring space is pressed on top of both stops. The forward or inner ring is the reverse stop ring and is installed first. The aft ring is the feathering stop ring. Both rings are identical and interchangeable and each one has aligning marks for the purpose of obtaining the correct reverse or feathering stop angle settings. Both stop rings have serrations on the inner diameter which fit over the serrations on the outer diameter of the rotating cam and gear in the dome. The rotary cam gear in the dome has certain teeth with degrees etched on them. The marked teeth are in the feathering and low pitch reverse angle ranges. Each tooth that is marked also has an etched mark at the serrations on the outer diameter which indicates the serration that corresponds to the degree mark. The mark may point to the valley of the serration or the crest of the serration, depending on the position of the gear tooth.

The angular distance from crest to valley is one degree; from crest to crest of each serration is two degrees. The rings are marked "SET LOW PITCH FIRST". However, the reverse blade angle is set by the first stop rather than the low pitch angle, the low pitch angle being determined by the stop lever assembly in the dome.

MODIFIED BRUSH BLOCK ASSEMBLY (See Figure 17A)

The brush block assembly is mounted on the nose case of each engine. The brush bracket is mounted on the block assembly by six screws and consists of the brush pad assembly with brushes, cover plate with electrical feed-thru and wirelon electrical leads contained in a flexible conduit. The wirelon electrical leads are continuous from the brush pad assembly to the firewall connector.

Slip Ring Assembly (See figure 17).

The slip ring assembly attached to the propeller hub provides a means of current transmission from the brush bracket assembly to the revolving propeller. The control brushes contact two face type slip rings.

Blade Cam Guard Assembly (See figure 17A)

Blade cam guard assemblies provide means of support for the control switch body assemblies on blades number 1 and 2 and support the counterweight on blade number 3. Each assembly is in two sections and attaches to the hub.

Blade Cam Assembly (See Figure 17A)

The blade cam on number one blade has two cam lobes. The larger lobe actuates the number 1 blade switch to terminate propeller unreversing whereas the smaller lobe actuates the switch to terminate unfeathering. The cam is positioned at propeller assembly so that continuity is established between the switch body assembly and ground at the end of the unreversing cycle at a blade angle of 5 to 7 degrees above the low pitch angle specified and continuity between the switch body assembly and ground will be broken to terminate unreversing at an angle in the constant speed range.

The blade cam assembly on number two blade has one lobe. The assembly is located so that the lobe breaks continuity between the switch body assembly and ground at an angle of 4 to 6 degrees above (numerically lower) the reverse angle specified to terminate auxiliary pump action during reversing operation.

PROPELLER GOVERNOR AND STEP MOTOR HEAD CONTROL SYSTEM (See figure 19).

The propeller governor is a double-acting, electrically operated type and is mounted on the right hand side of the engine nose case. It automatically makes adjustments in propeller blade angle necessary to maintain constant engine speed under varying flight conditions. All propeller operations (feathering, unfeathering, constant speed control, reversing and unreversing) are controlled through the governor during regular operations of the propeller.

The governor consists of a gear pump, pilot valve, relief valve system, selector valve, pump output check valve and an auxiliary pressure check valve. The pressure cut-out switch is not used and has been de-activated.

The governor gear pump takes oil from the engine supply through internal passages and boosts its pressure to that required for operation of the propeller pitch changing mechanism. The pilot valve, which is actuated by spring balanced fly weights, meters the oil to and from the propeller. The relief valve system limits the load on the gear pump, yet provides sufficient pressure to the propeller under all operating conditions. The selector valve directs the proper oil pressure (increase pitch pressure during constant speed operation and auxiliary pressure during feathering, unfeathering, reversing and unreversing) to back up the low pressure relief valve. The solenoid valve directs auxiliary high pressure oil to raise or lower the pilot valve hydraulically so that the governor pump output oil and auxiliary high pressure oil are directed to the proper side of the propeller piston. The pump output check valve prevents any possibility of reverse flow of oil through the governor pump in the event of governor drive failure. The auxiliary pressure check valve admits auxiliary oil into the governor oil passages to the propeller during the unfeathering and reversing cycles. Refer to "Operation of Propellers" for internal views of the governor during operation.

The accessories used with the governor are an auxiliary pump, a cockpit push-pull control switch, a solenoid relay, a commutator switch box, rpm control toggle switch and a full range limit indicator light. The auxiliary pump supplies the high pressure oil which is used to operate the propeller during the feathering and reversing cycles. The push-pull control switch is operated by the pilot to energize the solenoid relay which establishes the comparatively high current circuit between the aircraft power supply and the auxiliary pump. The push-pull cockpit control switch is pushed in to feather and pulled out to unfeather. The reversing action is accomplished by movement of the throttle, and through a system of relays and switches, the proper circuits are energized for reversing and unreversing. The rpm toggle switch, in conjunction with the commutator switch box, provides a means of setting the rpm which the governor is to maintain. Refer to Chapter 9 for throttle rigging.

RPM Control (See figure 19).

The governor has the Model five step motor electric head. Operation of the step motor head is determined by the characteristics of the step motor which is a permanent magnet rotor within a three-phase field winding. By changing the polarity (in the proper sequence) of the direct current applied to the field winding, the resultant field can be made to rotate in 30 degree steps in a direction determined by the sequence of polarity changes. The rotation of the magnetic field causes the rotor to turn and through a connecting gear train, the speeder spring adjusting rack is raised or lowered. The position of the rack adjusts the compression of the speeder spring to determine the engine rpm which the governor is to maintain.

The changes in polarity of the currents applied to the step motor windings are made by the commutator switch which is driven by a direct current motor. Each one of three contacts on the commutator switch is connected to one set of the field windings of the stepmotor. Since rotation of the commutator cams causes each contact to become alternately positive, zero, negative and zero, each winding of the step motor becomes energized by positive, zero, negative and zero impulses in the same manner. The sequence of these changes causes the field to rotate as explained above. Operation of the three-pole, double throw relay interchanges two of the three connections to the stepmotor and causes reversal of the sequence of polarity changes. Therefore, the direction of rotation of the step motor rotor is reversed.

As the magnetic field of the step motor rotates, it carries the rotor around with it, thereby operating the train of gears and, in turn, the speeder rack. The speeder rack is raised or lowered in the housing to vary the compression of the speeder spring of the control as necessary to adjust the rpm setting for the engine. A balancing spring is located above the rack in an intermediate position approximating cruising rpm in case there is a failure of the control head.

Two momentary toggle switches, placarded "PROP R.P.M." and having an "INCREASE" and "DECREASE" position are located just below the left throttle lever on the pilot's pedestal. These switches receive their power from the 28 volt d-c essential bus through circuits breakers placarded "L.H. PROP. R.P.M. CONT." and "R.H. PROP R.P.M. CONT." These switches operate the motor in the commutator switch box. A limit switch is mounted in the stepmotor head. When the limit of speeder rack travel has been reached the stop lug on the end of the control shaft contacts a stop on the housing. This makes an electrical contact which lights the "RPM RANGE LIMIT" indicator located just above and to either side of the "PROP RPM" switches on the pedestal.

The high and low rpm settings on the control head can be adjusted by loosening the self-locking nuts on the adjustment screws and

RPM Control (Cont.).

turning the screw in the desired direction. These adjustment screws are placarded "DEC. LOW R.P.M." and "INC. HIGH R.P.M." and have a direction arrow. One complete turn of the adjusting screw is equivalent to approximately 75 RPM. After adjustment is made, the locknuts should be tightened and the adjusting screws lockwired. Do not overtighten the locknuts.

Propeller Governor Constant Speed Operation. (See figure 6).

The double acting governor and step-motor control head control the constant speed operation, no engine oil pressure being used except to supply make-up oil loss due to seepage. The speeder spring compression against the governor fly-weights is adjusted by the "PROP RPM" control switch operating the control head motor.

During an engine overspeed condition, the governor fly-weights swing out from the center of rotation due to centrifugal force and raise the pilot valve against speeder spring compression. When the pilot valve lands are repositioned in this manner, governor pump pressure is applied to the forward side of the propeller piston through one of two sets of oil transfer passages in the nose case, propeller shaft, oil transfer housing, and the center tube of the low pitch stop lever assembly. The second set of transfer passages, leading from the governor to the aft side of the propeller, is connected to the suction side of the governor pump and serves as a return. The low pressure relief valve is subjected to governor pump pressure on both sides when the pilot valve is in the raised position. This causes the relief valve to be inoperative and the governor supplies the higher oil pressure necessary to increase the blade angle (decrease rpm) against the blade twisting moment which tends to move the blades to low pitch position.

During an engine underspeed condition, the speeder spring compression overcomes the centrifugal force of the fly weights, forcing them back toward the center of rotation, and forcing the pilot valve down. With the pilot valve in this position, the transfer passages leading to the aft side of the propeller piston are connected to the pressure side of the governor pump and those leading to the for-

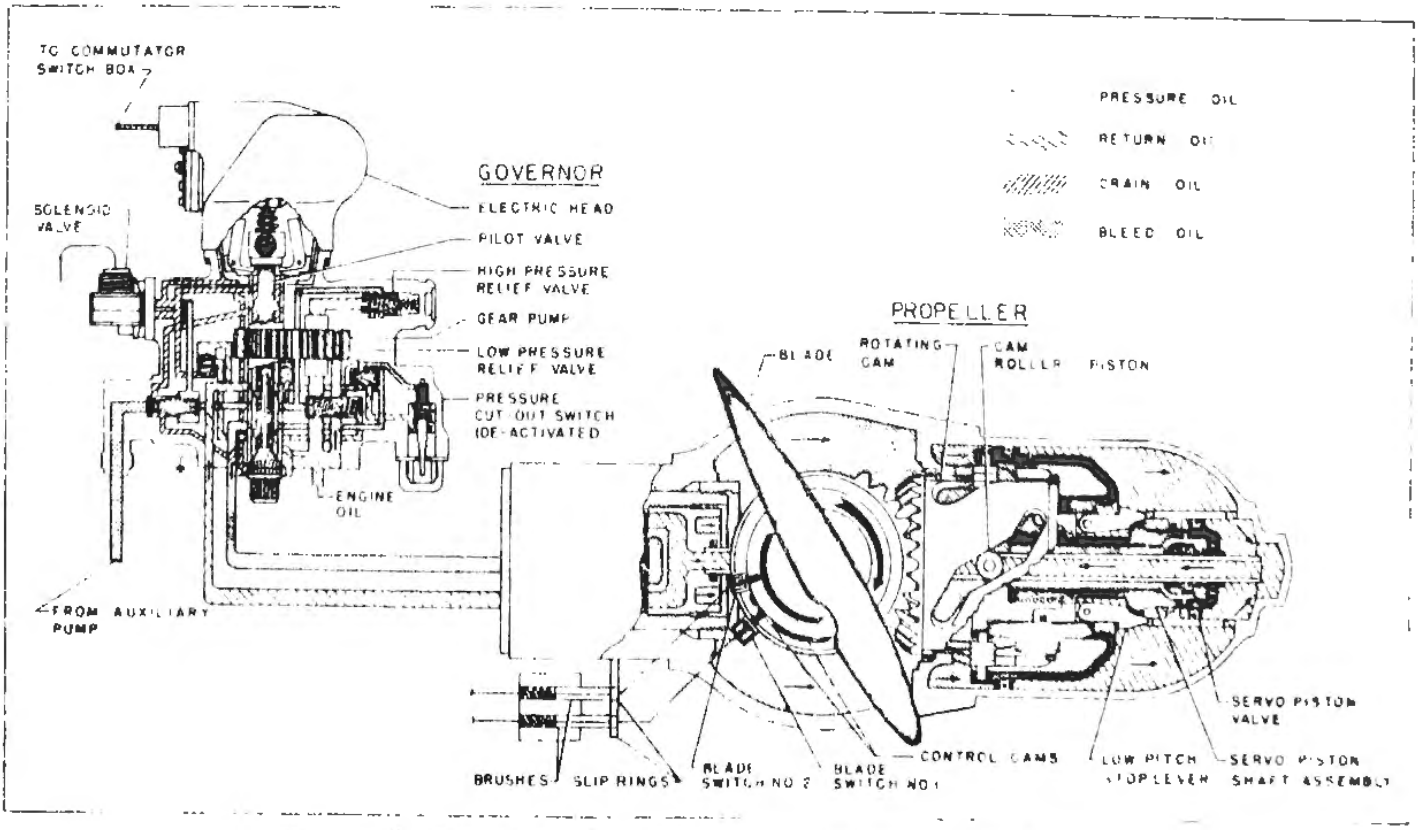


Figure 6. Propeller Constant Speed Hydraulic Schematic

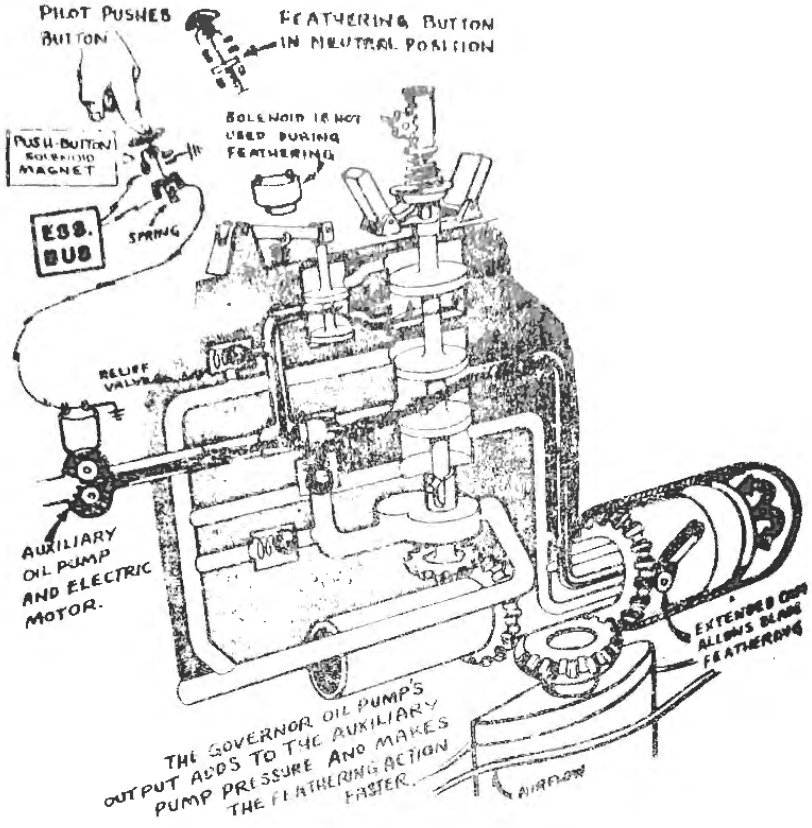
Propeller Governor Constant Speed Operation (Cont.).

ward side are connected to the suction side. The low pressure relief valve limits the governor pressure during underspeed condition since less pressure is required to move the blades to low pitch.

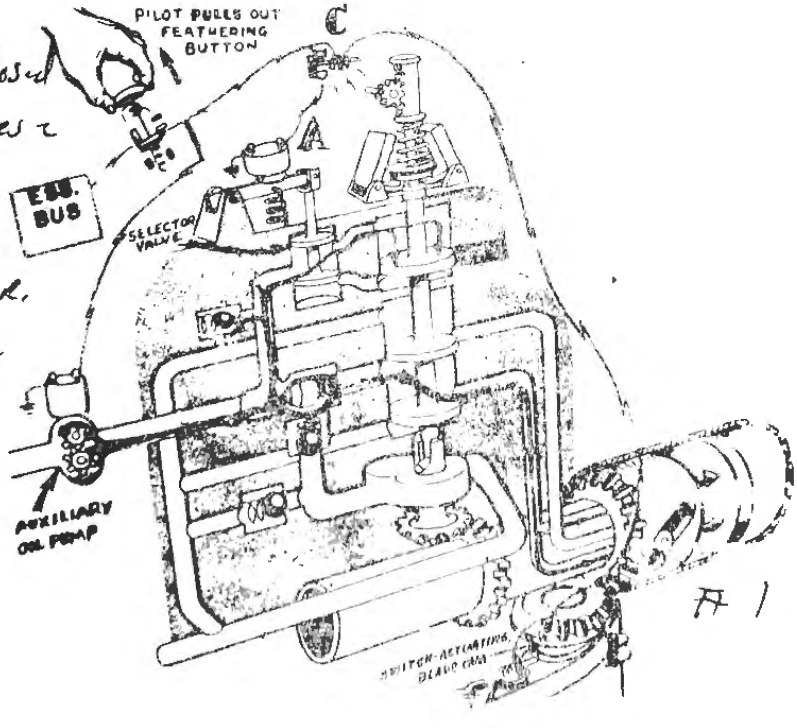
During onspeed conditions, the centrifugal force of the fly-weights balances the speeder spring compression, holding the pilot valve in a position which maintains sufficient differential pressure on each side of the propeller piston to prevent it from moving. The blade angle does not change in this condition because the propeller piston is held stationary.

ILLUSTRATIONS OF PROPELLER OPERATION

A. FEATHERING


PILOT PUSHES BUTTON
FEATHERING BUTTON IN NEUTRAL POSITION
SOLENOID IS NOT USED DURING FEATHERING
PUSH-BUTTON SOLENOID MAGNET
ESS. BUS
SPRING
RELIEF VALVE
AUXILIARY OIL PUMP AND ELECTRIC MOTOR.
EXTENDED CAM ALLOWS BLADE FEATHERING
THE GOVERNOR OIL PUMP'S OUTPUT ADDS TO THE AUXILIARY PUMP PRESSURE AND MAKES THE FEATHERING ACTION FASTER.

B. UNFEATHERING



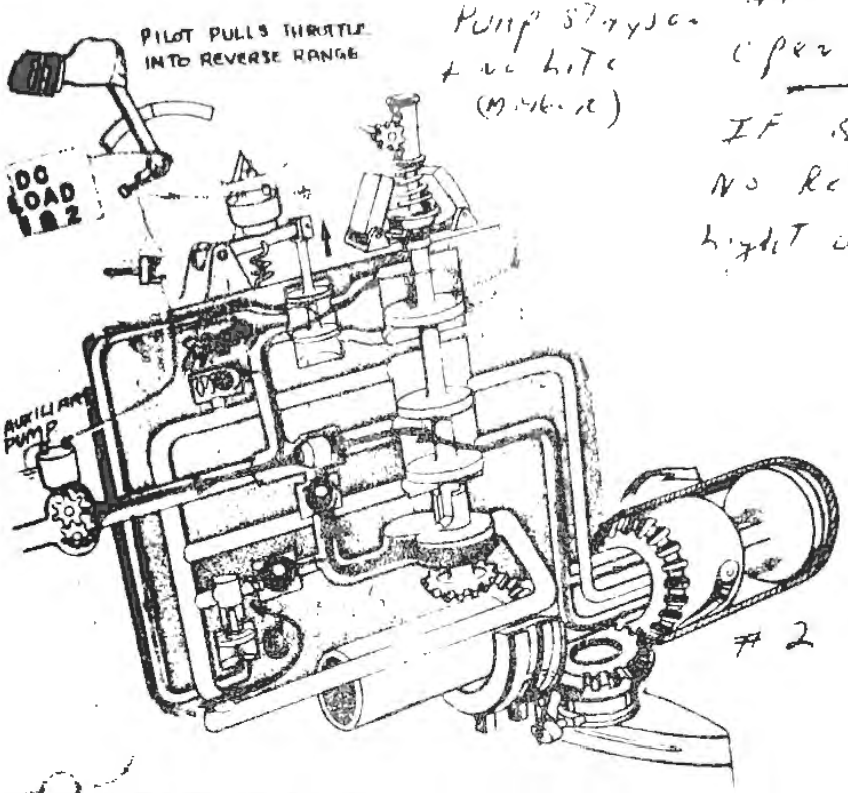
IF Blade Sw. STICKS closed Prop will Reverse

If Sw. Sticks open No Oper. will Take place

A/ Blade Sw.

++ ILLUSTRATIONS OF PROPELLER OPERATION

C. REVERSING



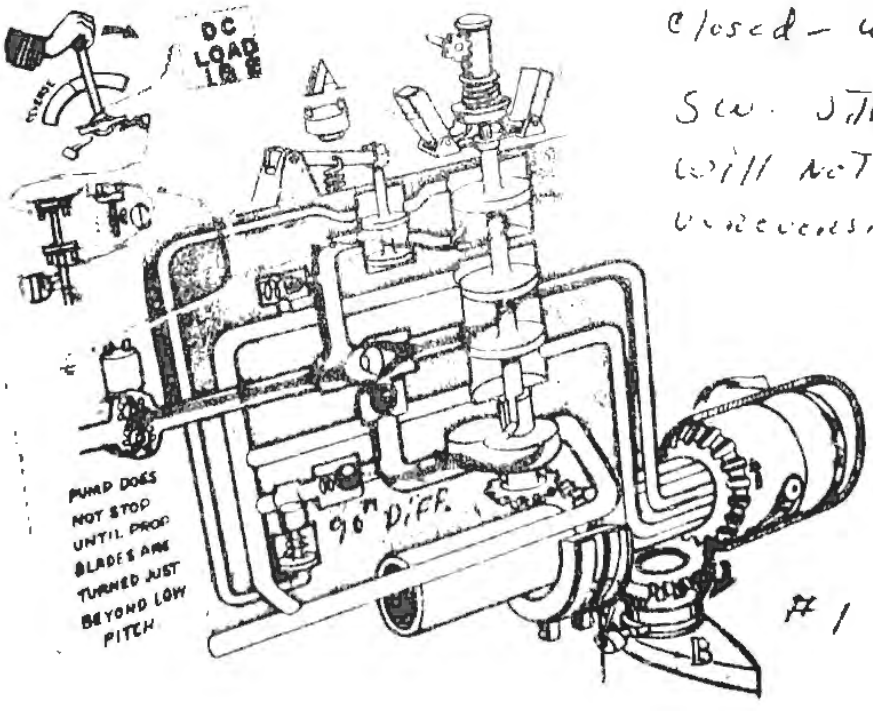
Pump starts + Amber Lite (Reverse)

IF Blade sw STICKS open - [illegible]

IF sw. shorts out No Reversing - BUT Amber light would come on.

#2 Blade sw.

D. UNREVERSING



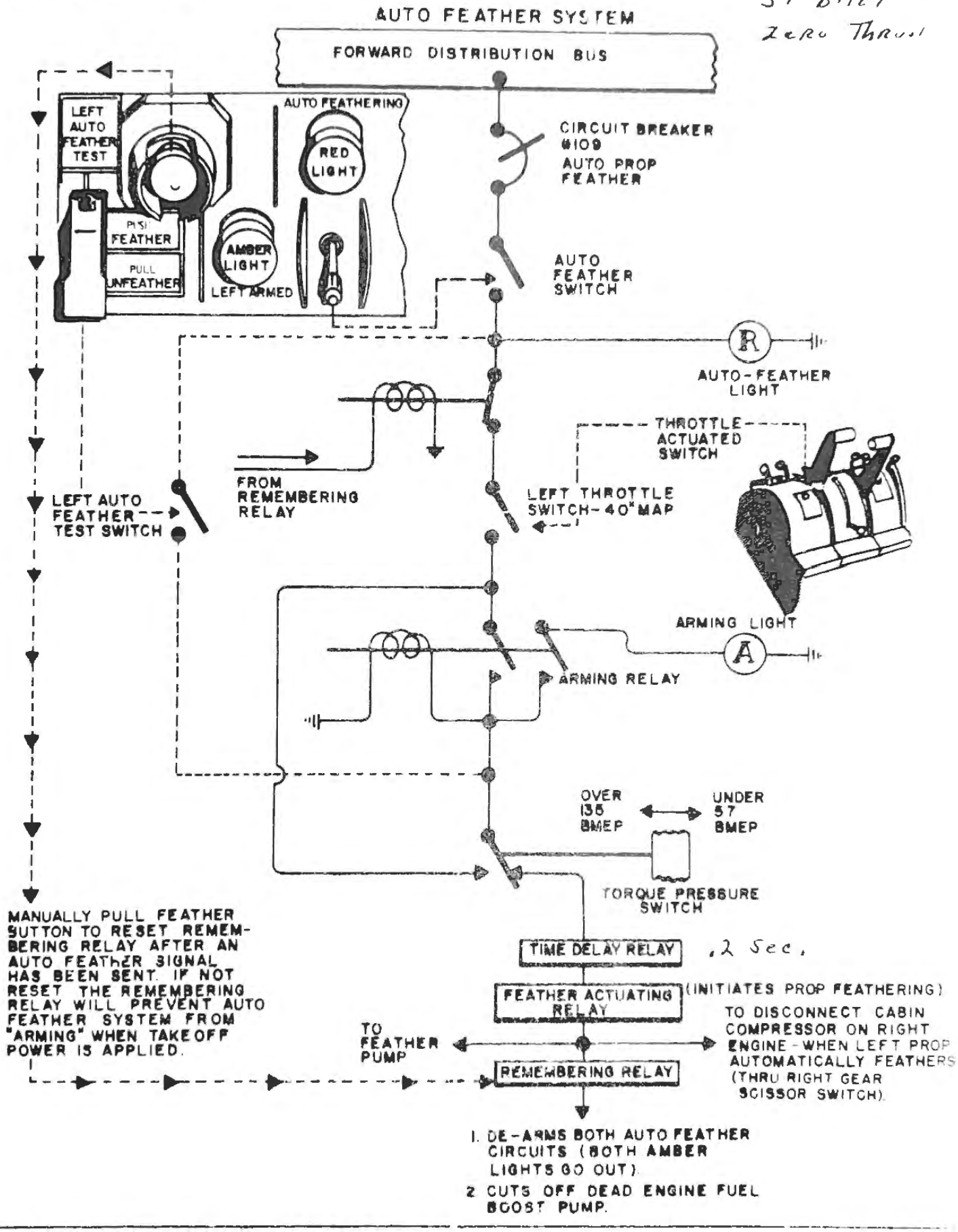
Blade sw STICKS Closed - Will NOT Unreverse

Sw. STICKS open Will NOT Terminate Unreversing

#1 Blade sw

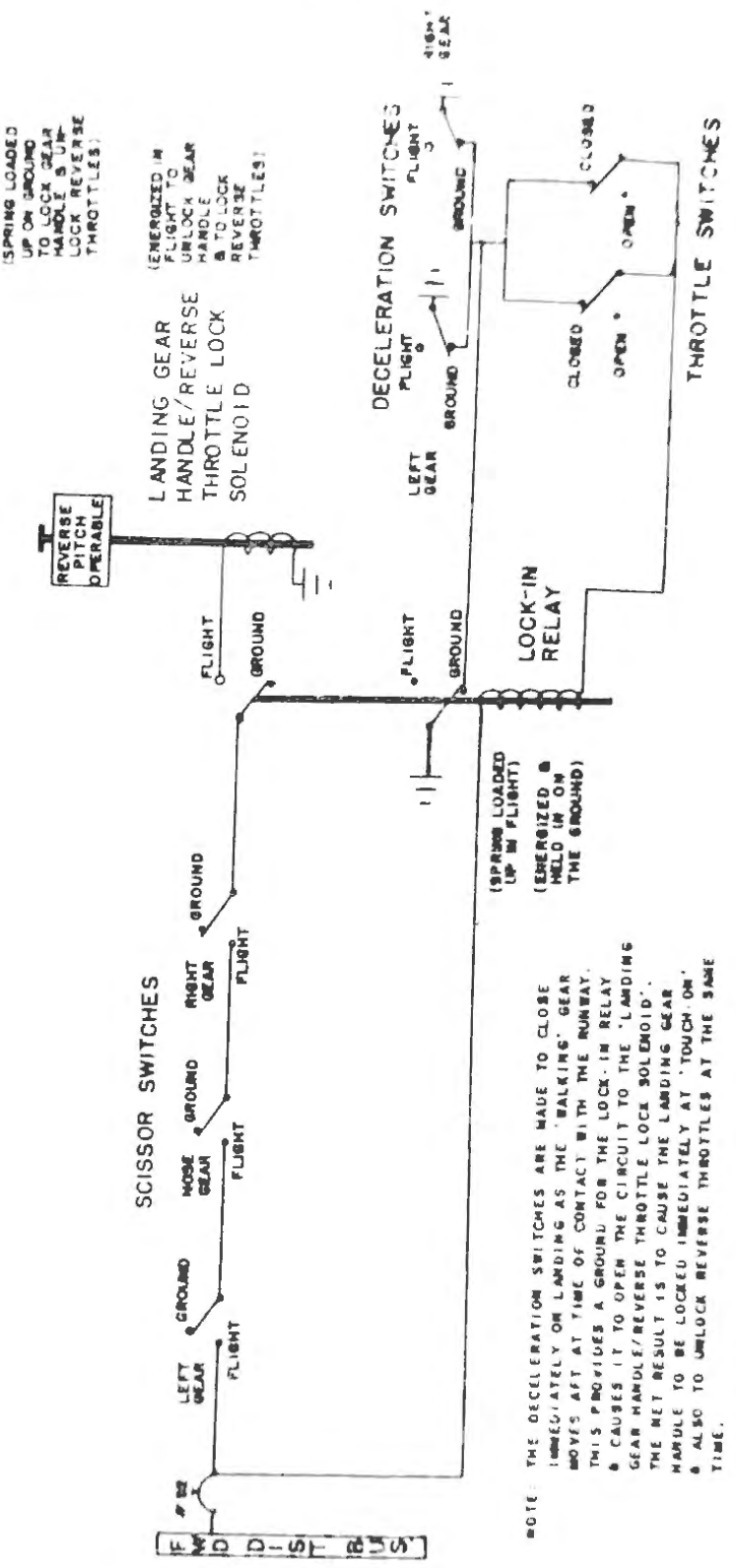
F. AUTO-FEATHER SYSTEM

57 BMEP
Zero Thrust


AUTO FEATHER SYSTEM
FORWARD DISTRIBUTION BUS
LEFT AUTO FEATHER TEST
AUTO FEATHERING
RED LIGHT
PUSH FEATHER
PULL UNFEATHER
AMBER LIGHT
LEFT ARMED
CIRCUIT BREAKER #109
AUTO PROP FEATHER
AUTO FEATHER SWITCH
R
AUTO-FEATHER LIGHT
THROTTLE ACTUATED SWITCH
FROM REMEMBERING RELAY
LEFT THROTTLE SWITCH-40" MAP
LEFT AUTO FEATHER TEST SWITCH
ARMING LIGHT
A
ARMING RELAY
OVER 135 BMEP
UNDER 57 BMEP
TORQUE PRESSURE SWITCH
MANUALLY PULL FEATHER BUTTON TO RESET REMEMBERING RELAY AFTER AN AUTO FEATHER SIGNAL HAS BEEN SENT. IF NOT RESET THE REMEMBERING RELAY WILL PREVENT AUTO FEATHER SYSTEM FROM "ARMING" WHEN TAKE OFF POWER IS APPLIED.
TIME DELAY RELAY
.2 Sec.
FEATHER ACTUATING RELAY
(INITIATES PROP FEATHERING)
TO FEATHER PUMP
TO DISCONNECT CABIN COMPRESSOR ON RIGHT ENGINE - WHEN LEFT PROP AUTOMATICALLY FEATHERS (THRU RIGHT GEAR SCISSOR SWITCH).
REMEMBERING RELAY
1. DE-ARMS BOTH AUTO FEATHER CIRCUITS (BOTH AMBER LIGHTS GO OUT).
2 CUTS OFF DEAD ENGINE FUEL BOOST PUMP.

ILLUSTRATIONS OF PROPELLER OPERATION

LANDING GEAR HANDLE/REVERSE THROTTLE LOCK SCHEMATIC - 404


(SPRING LOADED UP ON GROUND TO LOCK GEAR HANDLE & UNLOCK REVERSE THROTTLES)
(ENERGIZED IN FLIGHT TO UNLOCK GEAR HANDLE & TO LOCK REVERSE THROTTLES)
LANDING GEAR HANDLE/REVERSE THROTTLE LOCK SOLENOID
REVERSE PITCH OPERABLE
DECELERATION SWITCHES
RIGHT GEAR
FLIGHT
GROUND
LEFT GEAR
CLOSED
OPEN
THROTTLE SWITCHES
LOCK-IN RELAY
(SPRING LOADED UP IN FLIGHT)
(ENERGIZED & HELD IN ON THE GROUND)
SCISSOR SWITCHES
NOSE GEAR
END-OF RSW
NOTE THE DECELERATION SWITCHES ARE MADE TO CLOSE IMMEDIATELY ON LANDING AS THE 'WALKING' GEAR MOVES AFT AT TIME OF CONTACT WITH THE RUNWAY. THIS PROVIDES A GROUND FOR THE LOCK-IN RELAY & CAUSES IT TO OPEN THE CIRCUIT TO THE 'LANDING GEAR HANDLE/REVERSE THROTTLE LOCK SOLENOID'. THE NET RESULT IS TO CAUSE THE LANDING GEAR HANDLE TO BE LOCKED IMMEDIATELY AT 'TOUCH ON' & ALSO TO UNLOCK REVERSE THROTTLES AT THE SAME TIME.
IN EVENT OF A 'TOUCH AND GO' LANDING THE LANDING GEAR HANDLE WILL BE UNLOCKED WHEN BOTH THROTTLES ARE OPEN AND THE WEIGHT IS OFF THE GEAR

Left Gear Sw
Opens Outflow Valve on Ldg.

Nose Gear Sw
Turns off Air Stop Blanket
(Even if Sw. still on)

Rt. Rear Sw.
Turns off Fuel
disconnect Primary Engine

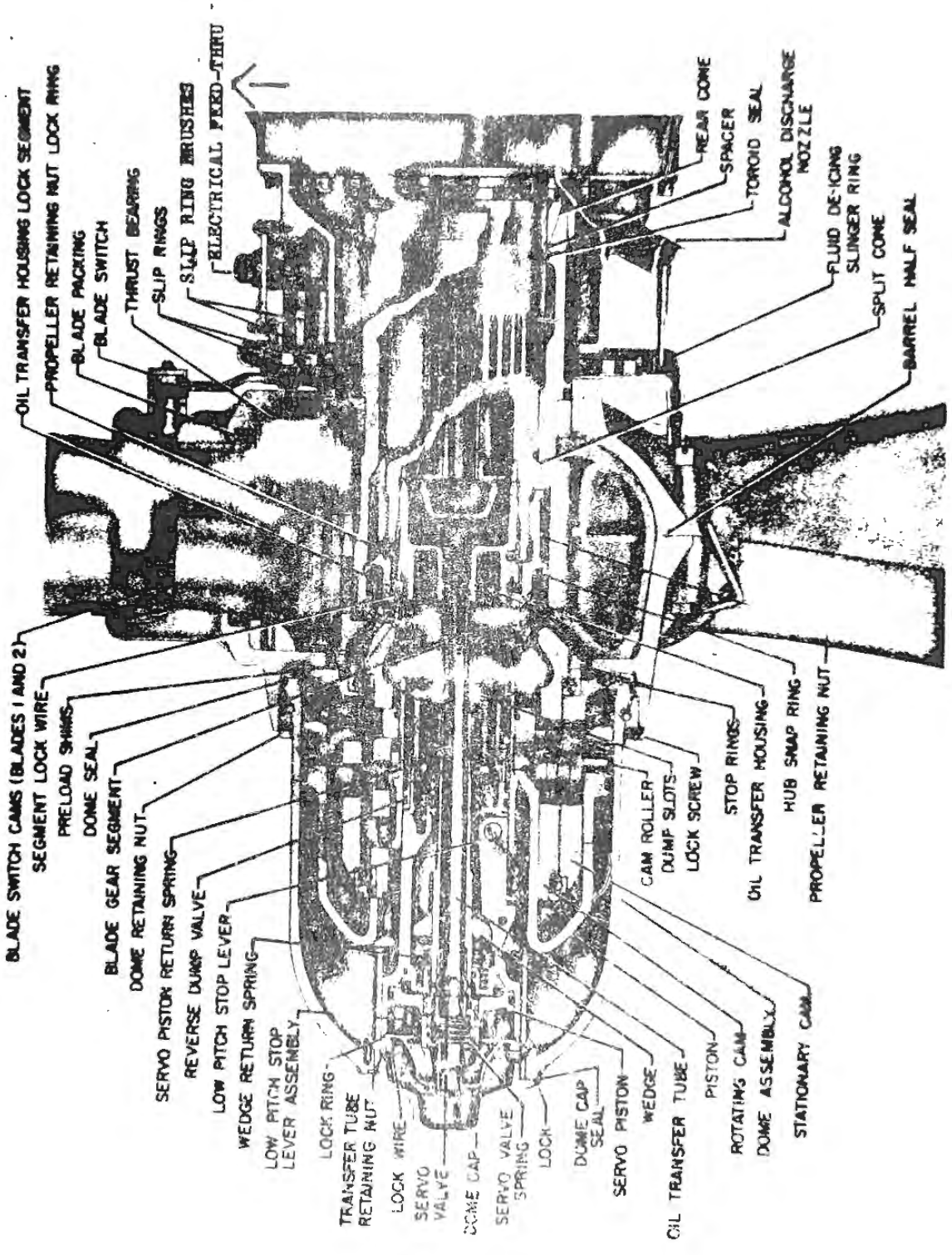


Figure 11. Propeller Assembly (Cut-A-Way)

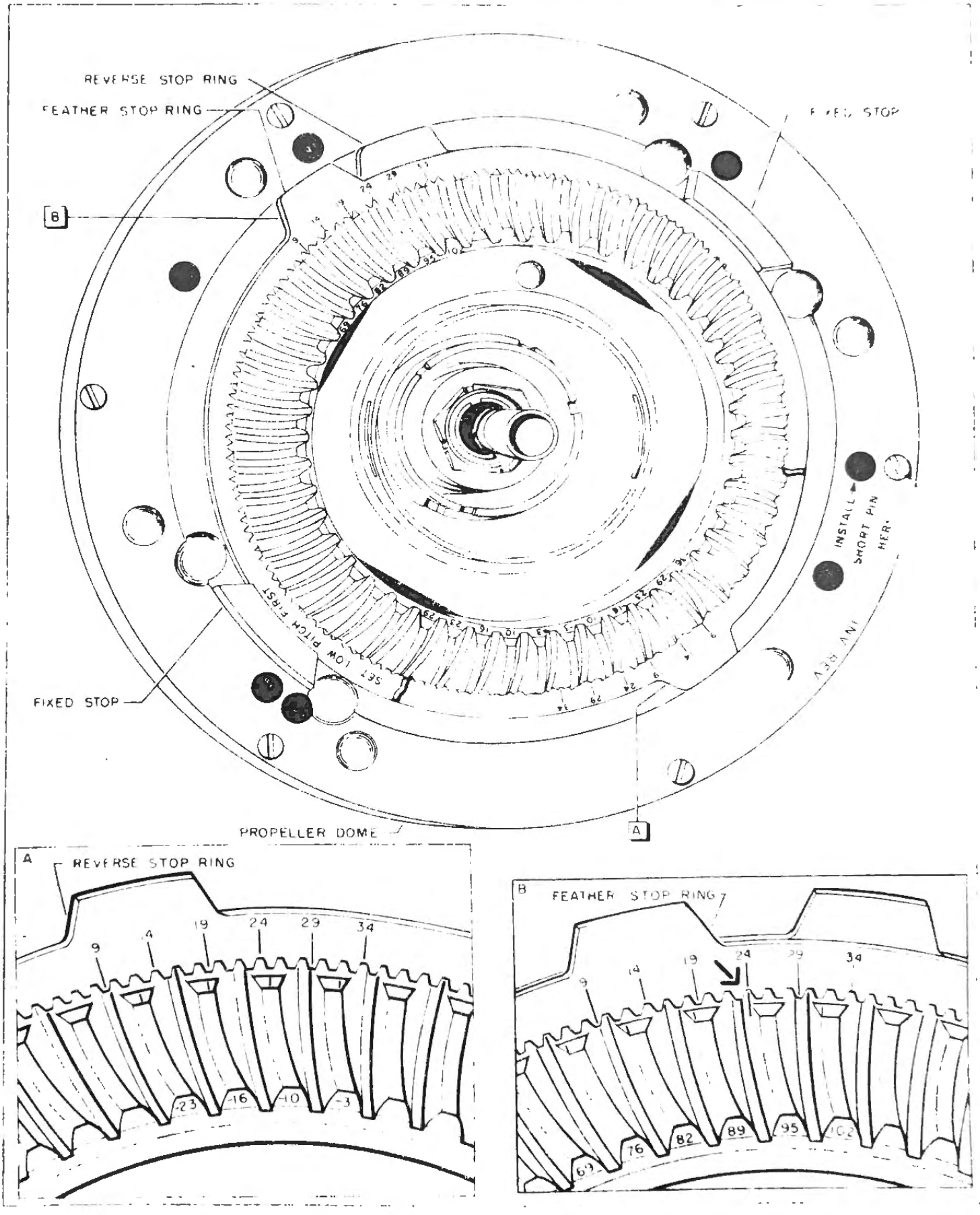


Figure 7-. Propeller Feather and Reverse Pitch Stop Ring Setting

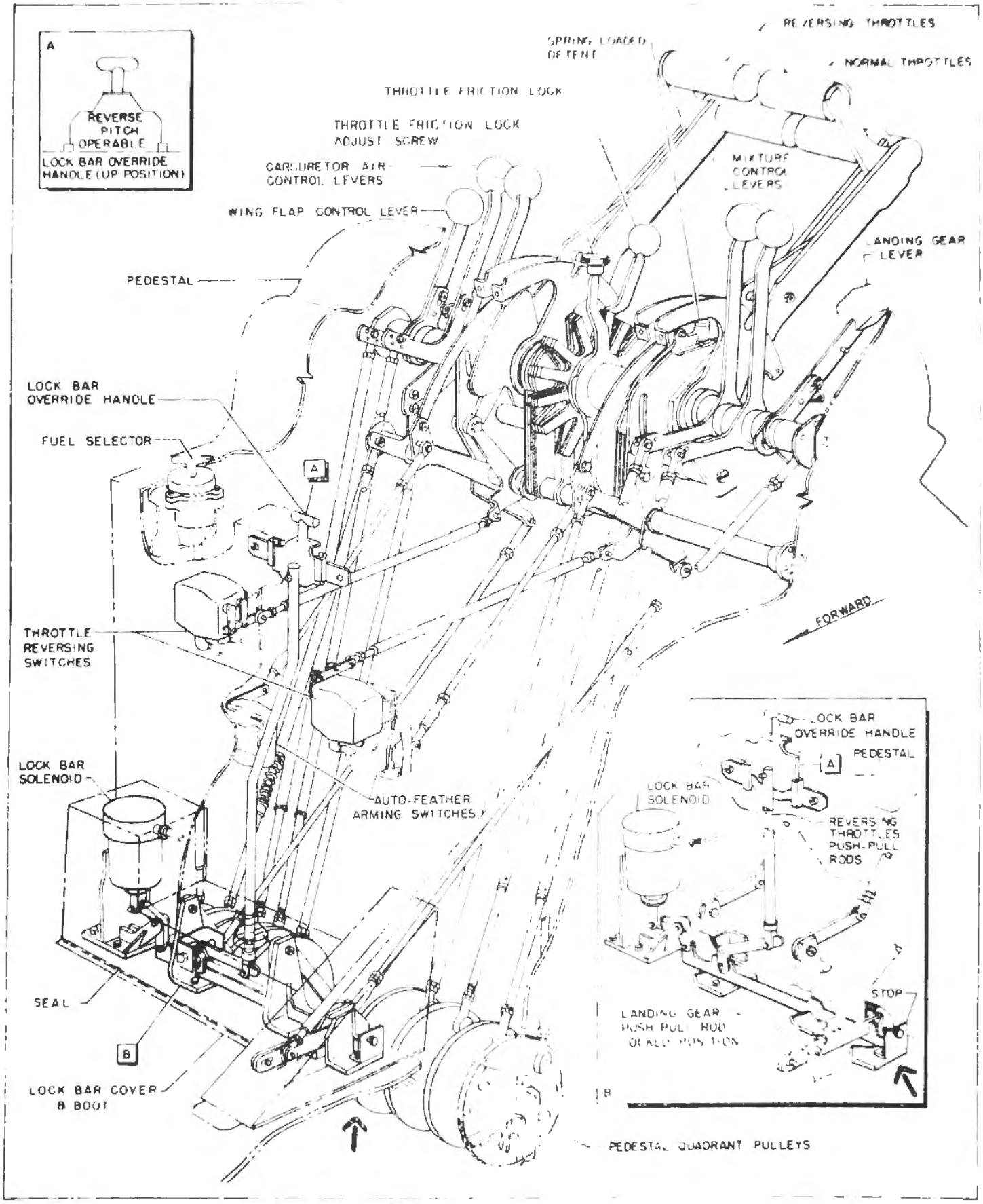
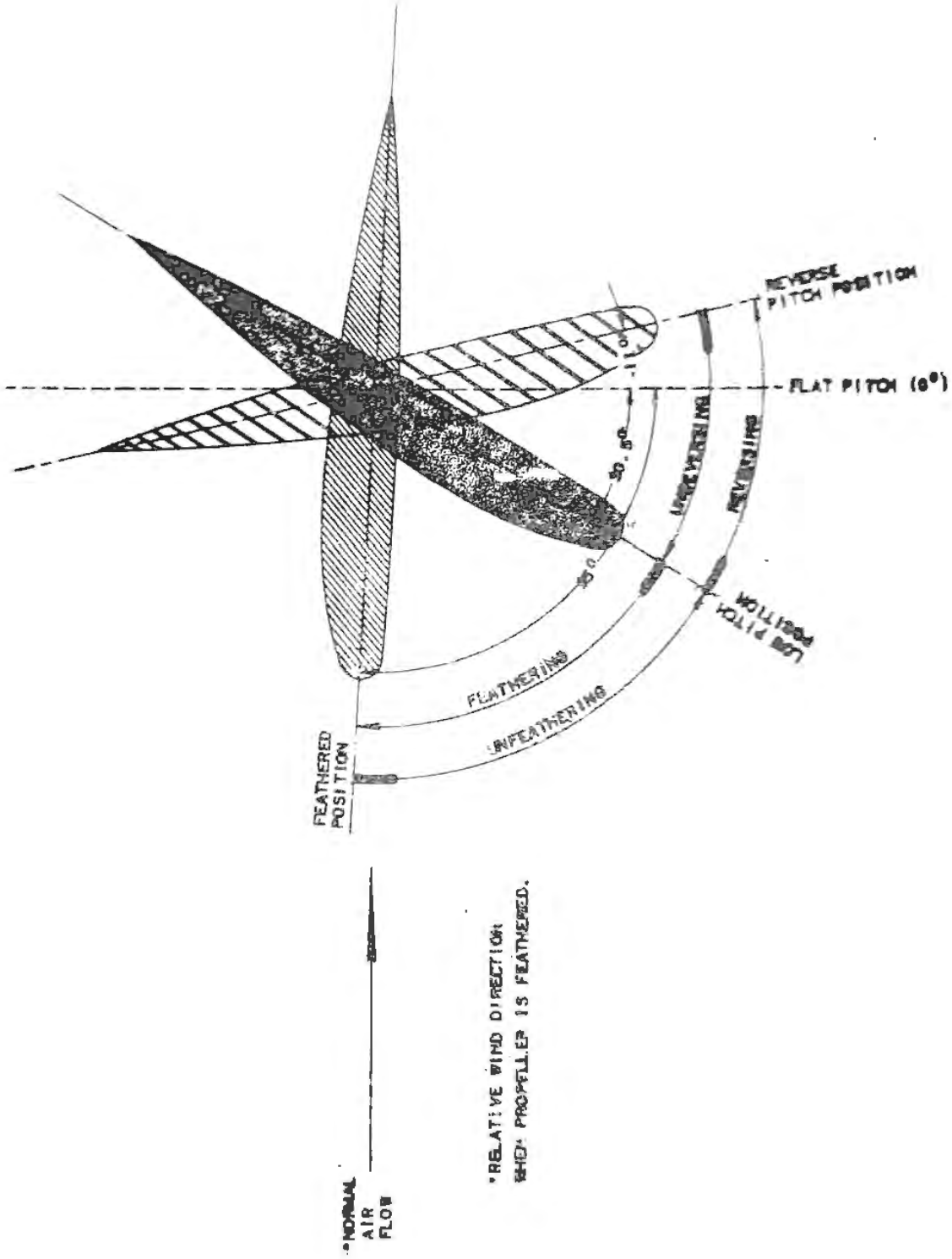


Figure 13. Pedestal Assembly (Sheet 1 of 2 Sheets)

ILLUSTRATIONS OF PROPELLER OPERATION

F. BLADE ANGLE POSITIONS

PROPELLER BLADE ANGLE POSITIONS



LANDING GEAR - GENERAL (See figure 14)

The tricycle-type landing gear is hydraulically operated and the main gears retract forward into the engine nacelle while the nose gear retracts forward into a wheel well in the fuselage nose section. The wheel wells are enclosed by linkage actuated doors consisting of left and right assemblies which are so designed that the doors open for gear passage, then close again when the gear has reached full up or full down position. The main gear is of the single oleo, dual wheel type and is equipped with hydraulic brakes. The single-wheel, nose gear is steerable. A separate nose gear shimmy damper system is provided to reduce or eliminate nose wheel shimmy.

Landing Gear Operation.

The gears are extended and retracted by a control lever on the pilot's pedestal which is linked to a valve in the hydraulic system. In the event of hydraulic failure, the gears may be released manually by a cable system connected to the up-lock mechanism of the nose and main gears. Refer to Emergency Up-Lock Release System for further description.

An emergency "down" hydraulic circuit is provided to lock the gears in the down position if they fail to lock after manual release.

Steering is accomplished through a wheel mounted on the pilot's forward console. This wheel is linked to a valve in the hydraulic system, which governs flow of hydraulic fluid to the steering cylinder on the nose gear. A mechanical follow up linkage provides control of the steering cycle when the desired degree of turn is reached. The actuation of the steering control and the motion of the follow-up linkage is almost simultaneous. For further description refer to Nose Wheel Steering And Shimmy Damping.

Main Landing Gear Doors And Linkage. (See figure 28).

The main landing gear doors are broken down into three separate sections. The aft section serves to close a narrow opening for the oleo and drag link and a pair of edge hinged doors close the larger opening in the nacelle required for the dual wheels.

The aft section is hinged at its aft extremity and operated by the gear itself through a short, swiveled rod, which is attached to the lower section of the oleo, immediately aft of the drag link attachment. This door, which is actuated by direct connection to the gear, opens when the gear is extended, and remains open until the gear is retracted.

The larger forward doors are split along the fore and aft center line of the nacelle, and are hinged at the upper edges. They are actuated by the movement of the gear, but through a more complex linkage providing for the doors starting to open as the gear starts down, reaching full opening for the passage of the dual wheels, but closing tight again when the gear reaches full extension. Upon retracting the gear, the doors again go through this same cycle, ending again with fully closed doors when the gear is fully retracted. This linkage begins with an arm fixed to each trunnion arm at the upper part of the gear, providing a pivot point for a push pull rod running forward to the aft edge of the doors. This pivot point provides for full closing of the doors for both extreme positions of the gear. From the aforementioned fore and aft push pull rods, the motion is transferred through torque tubes to the trunnion arms. At the opposite ends of the two torque tubes, a bellcrank transfers the motion to a link attached by a swiveling joint to the doors. From this last mentioned bellcrank, a second arm is used in conjunction with another push pull rod to arrange a parallelogram linkage to another bellcrank and link at the forward end of the door, where the attachment is also by a link with a swiveling attachment to the door itself.

To provide for easier access to the interior of the wheel well for servicing, a de-clutching mechanism has been provided in the ends of the torque tubes, which will allow the main gear doors to be opened while the airplane is on the ground without the necessity of disconnecting any of the described linkage.

Provisions have been made in the attachment of the forward main gear door operating rods to the main gear trunnions to allow for aft movement of the main landing gear when landing and on brake application. Refer to Main Landing Gear Door Compensating Mechanism.

Main Gear Oleo Drag Strut (See figure 1).

The main gear drag strut is a two piece, center hinging strut. The lower end of the strut is attached to a fitting on the main gear shock strut and the upper end is attached to a structural fitting on the front spar. With the gear extended and locked the drag strut assumes a straight line between its two points of attachment, and functions to transmit all fore and aft gear loads to the wing. The upper half of the drag strut is a self-contained air-oil strut, capable of acting as a shock absorber for tension loads applied to the drag strut on landing and brake application, but acting as a solid section for compression loads. The air oil strut is essentially a cylinder whose piston has a much greater area on one side than the other. The hydraulic fluid and air under pressure acting on the side of the piston with the greater area, keeps the piston bottomed against the side with the lesser area. The piston rod of the cylinder is attached to the structure at the front spar and the cylinder extend under tension loads allowing the main gear to move aft absorbing landing shock.

When the cylinder extends, with these tension loads, the cylinder portion of the strut moves down causing the piston to leave its seated

Main Gear Oleo Drag Strut (Cont.).

position and to move toward the air and fluid reservoir portion of the strut. This movement draws the large diameter piston rod, on the side of the piston with the lesser area, into the strut cavity. This reduces the volume within the cavity thereby resulting in fluid being forced through the cylinder orifice into the fluid reservoir and air cavity of the strut. This movement of fluid further compresses the air thereby increasing its resistance to strut extension and giving it the desired shock absorbing quality. The metering of fluid serves to restrict speed of motion thereby serving as a damper. At the time cylinder movement started, fluid also passed through a check valve and orifice in the piston to occupy space created as the piston was unseated. When the tension load which extended the strut is removed, the previously discussed air and fluid pressure acting on the side of the piston with the greater area will again tend to reverse the above mentioned motion and flow until the piston is again seated. During return to a seated position, the check valve in the piston will be seated and all fluid on the side of the piston with the lesser area will be forced through the orifice in the piston. This will restrict speed of piston return thereby acting as a damper.

When the air-oil strut extends under tension loads of landing or brake application, a differential mechanism attached to the upper drag strut bolt and linked to the strut cylinder and gear actuating cylinder permits the actuating cylinder to move down and aft with the aft movement of the main landing gear (See figure 46). Similar provisions are provided on the forward landing gear door operating mechanism. Refer to Main Landing Gear Doors And Linkage. When jacking at either main gear a jack lockpin must be installed in the oleo drag strut to prevent it from extending. Refer to Jacking For Servicing Main Gear Wheels and Brakes, Chapter 1 for further information.

(Cont. on next page)

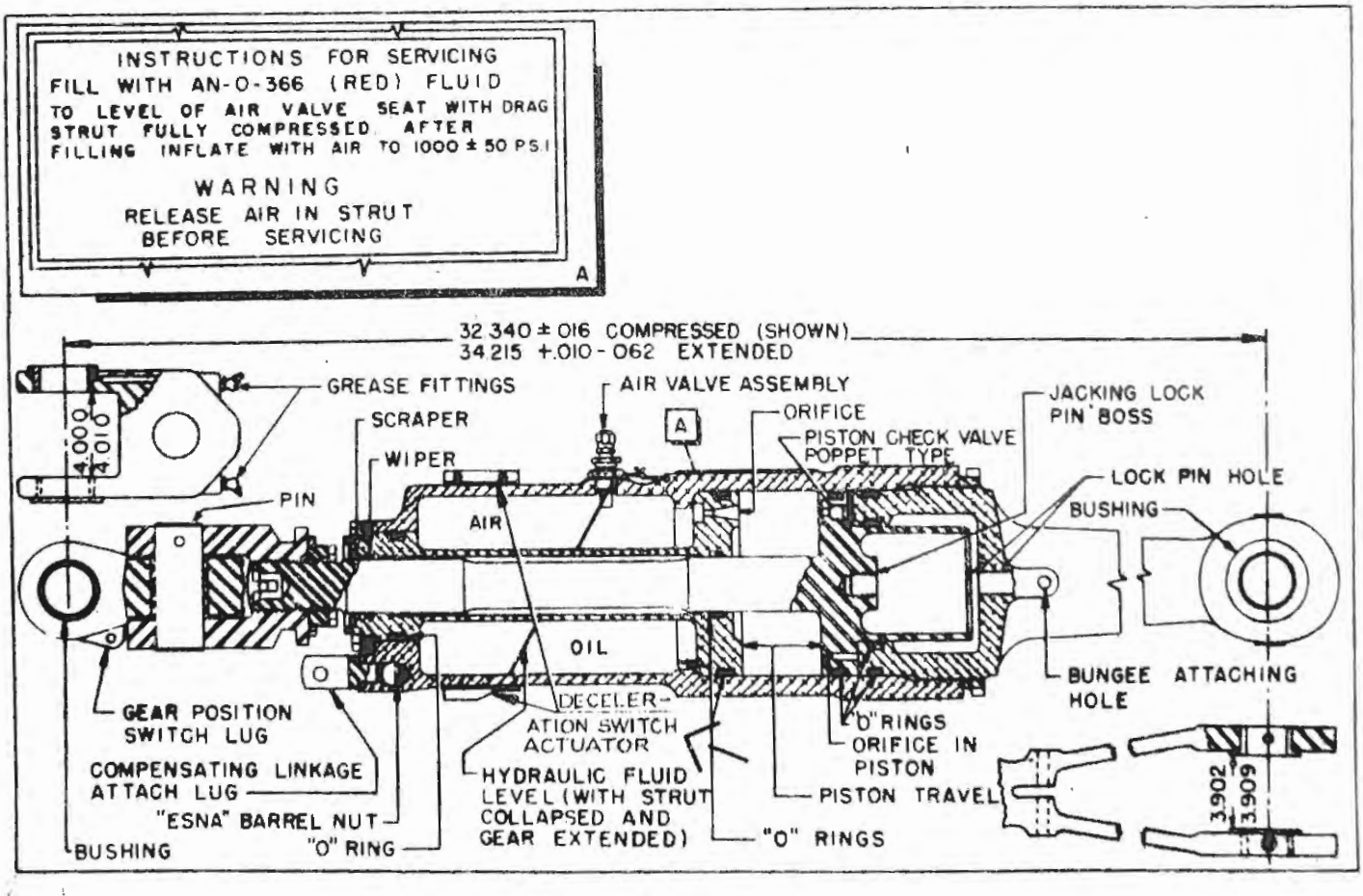


Figure 1. Main Landing Gear Drag Strut

Main Gear Oleo Drag Strut (Cont.).

The drag strut cylinder is filled with hydraulic fluid through the air valve body hole and charged with 1000 ± 50 psi of dry compressed air after the air valve is replaced.

WARNING

If strut is filled on the airplane the hydraulic fluid must be level with the air valve body hole with gear extended and strut fully compressed. The strut must NEVER be filled in the horizontal position. If strut is serviced on bench it must first be fully compressed and the SWIVEL END ELEVATED 60 degrees from horizontal before filling with fluid. During initial filling of a strut it is necessary to work the piston back and forth full travel several times to insure the escape of trapped air and the complete filling of lower piston cavity. NEVER use oxygen or acetylene for charging as these gases are highly explosive under certain conditions. The air valve used in this unit is the new type which requires a new procedure for inflating and deflating. Refer to Air Valves and Cores, Chapter 16, for details.

Only high pressure air valve cores, identified by "H" on the top of the valve core stem may be used.

Main Gear Shock Strut.

The conventional shock struts are of the combined hydraulic and pneumatic type. They are interchangeable from left to right except for the crankshafts. Both air and fluid are utilized in the shock struts to produce controlled shock resistance during take off and landing of the airplane.

The static weight of the airplane is carried by the air in the upper chamber, which also serves to keep the oleo extended so that it is in a position to take the next shock load.

The impact energy of the landing airplane and the energy developed during taxiing is absorbed by both the air and the fluid.

The shock strut is filled with hydraulic oil level with the air valve body hole with the strut fully compressed. High pressure air valve cores are used in the shock strut. Refer to Air Valves And Cores, Chapter 16 for description and method of releasing air in the strut.

The shock strut will not require extensive servicing between overhaul periods, but periodical checks should be made for correct inflation of strut. Excessive leakage of hydraulic oil requires replacement of the strut, as the 'O' ring seals in the strut cannot be tightened.

Main Gear Lock Linkage (See figure 2).

The main gear lock linkage is a two-piece folding member connecting the center hinge point of the drag strut to the crankshaft running across the trunnions at the top of the gear. The lock linkage assumes a straight line between the center pivot point of the drag strut and the crankshaft when the gear is either in the

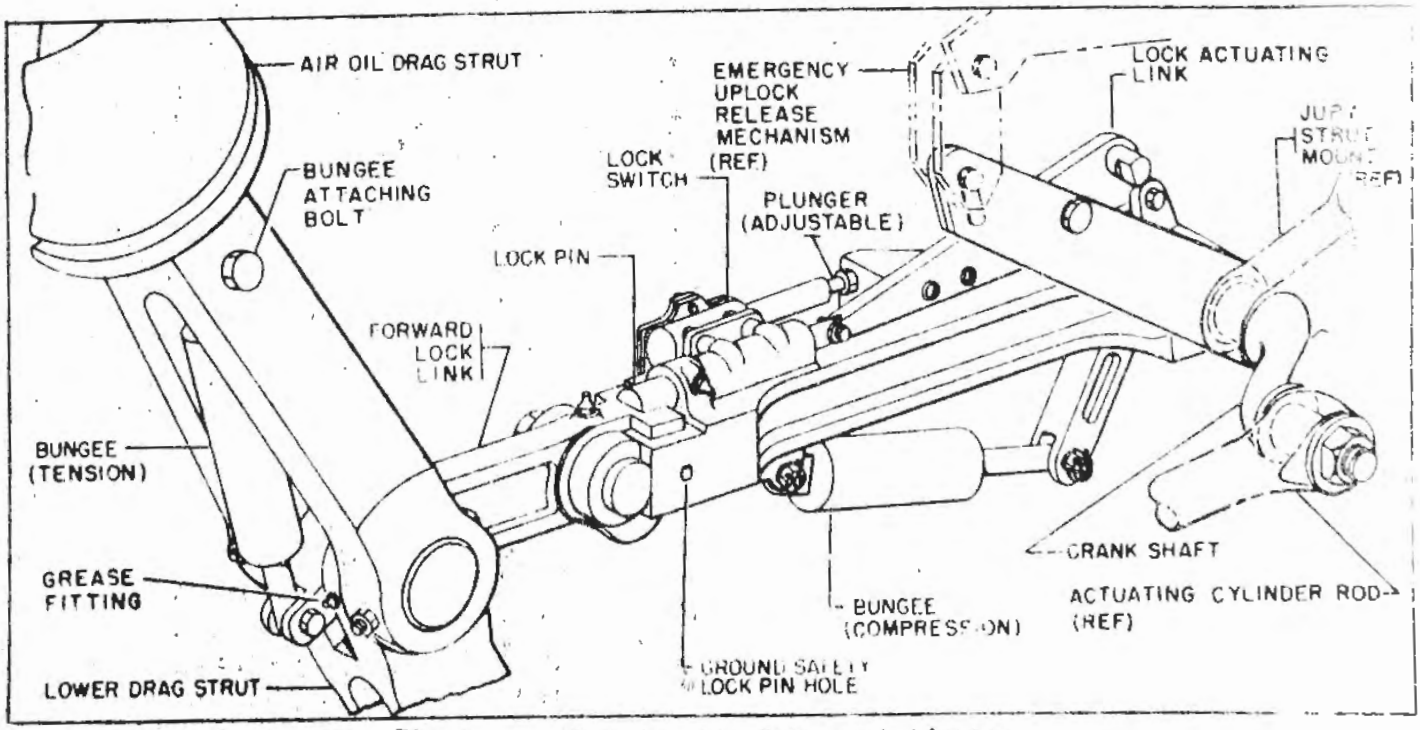


Figure 2. Main Landing Gear Lock Linkage

Main Gear Lock Linkage (Cont.).

extended or retracted position. The lock linkage is held in its straight line position by a spring loaded lockpin, which is extracted by the initial movement of the actuating cylinder acting on the crankshaft.

A tension bungee attached between the upper drag strut and the forward end of the lock linkage functions to straighten the lock linkage when the gear reaches full travel in either direction. A compression bungee which is mounted beneath the jury strut and actuated by the crankshaft of the main gear, functions to force the lockpin into locked position when the lock linkage straightens out. A lock switch is mounted on the side of the lock and is positively actuated in both directions by means of a bracket on the lock actuating link. Refer to Operation of Landing Gear Indication for operation of this switch. An emergency up-lock manually operated release mechanism is connected to the up-lock mechanism of each main gear, refer to Emergency Up-Lock Release System for further description. Provisions have been made in the gear lock linkage members for installation of ground safety lock pins, which when installed, prevent accidental retraction of the gear while the airplane is on the ground, refer to Landing Gear Lock Pins Chapter 1 for further description and use. For lubrication of the main gear lock linkage refer to Chapter 14.

Main Landing Gear Door Compensating Mechanism (See Figure 3).

Provisions have been made in the attachment of the forward main gear door operating arms to the main gear trunnion arms to permit the aft movement of the main gear due to the extension of the drag strut at "touch-down" or on brake application. The bolt which connects the aft end of the respective door operating arm to the gear trunnion arm is free to move forward and aft in a slotted link. This permits the door operating arms to remain stationary when the landing gear moves aft. Two tension springs attached between the hinge point of the arm and link assemblies, and the door trunnion arms keeps tension on the compensating linkage.

Main Landing Gear (See figure 16).

Each main gear consists of an air-oil shock strut, a two-section drag strut, an axle, two wheel and brake assemblies, two tires and two tubes. The upper portion or trunnion of the gear attaches to, and pivots in a truss fitting built into the wheel well between the spars. This trunnion is an integral part of the main shock strut. The two piece drag strut is attached between the lower portion of the main shock strut and a fitting on the aft side of the front spar. The lock linkage is attached between the crankshaft at the top of the shock strut and the center pivot point in the two piece drag strut. The hydraulic cylinder for actuating the main gear is connected between the crank pin of the crankshaft at the top of the shock strut and a fitting just aft of the front spar. The axle, an integral part of the shock strut piston, extends to right and left of the bottom of the piston, and carries the two wheel and brake assemblies. The forward

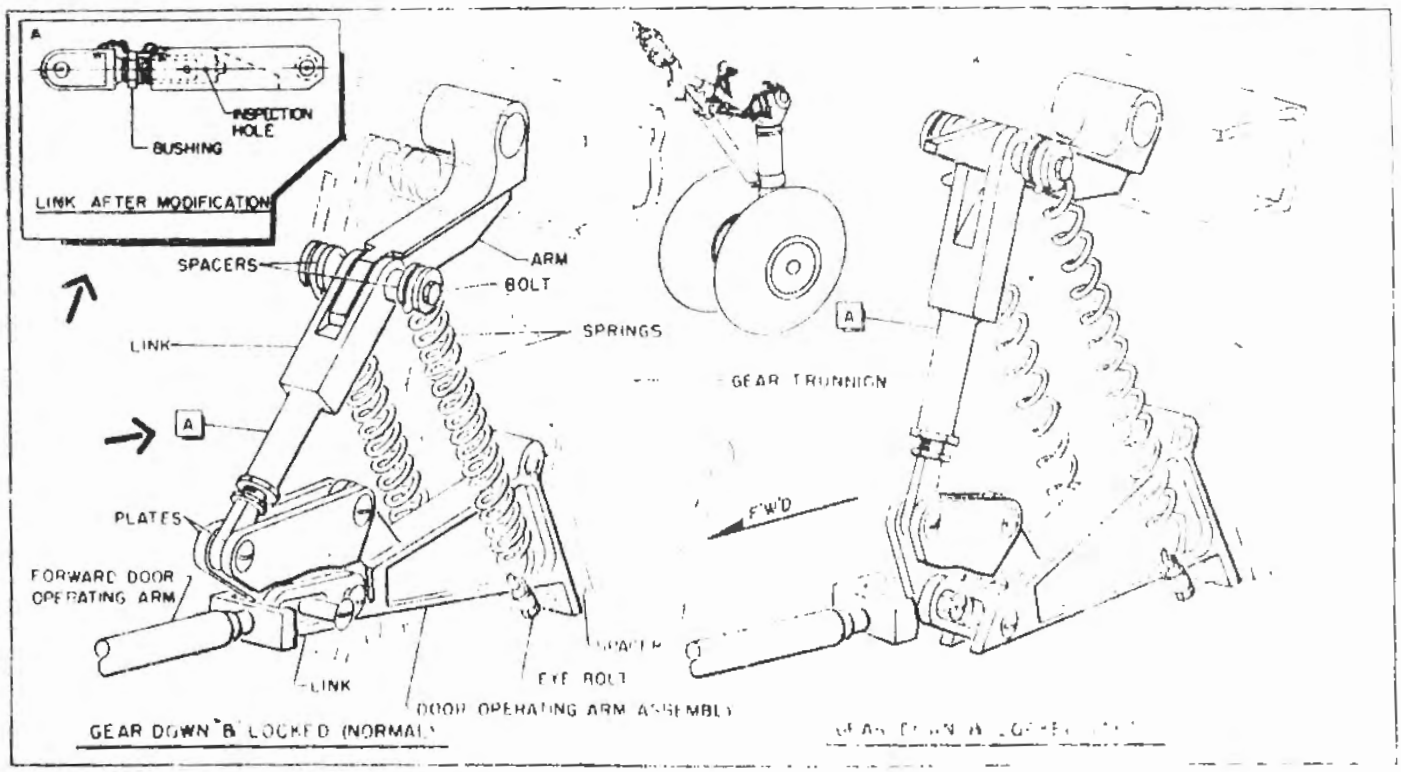


Figure 3. Main Landing Gear Door Compensating Mechanism

MAIN LANDING GEAR (CONT.)

door actuating mechanism is attached to fittings on the trunnion arms. A plunger type lock switch is attached to the jury strut of the main gear and actuated by the lock linkage. The scissor switch is mounted on a clamp attached to the shock strut and actuated by a lever attached to the scissor torque arm. The position switch, which is located in the nacelle is actuated by a lever attached to the upper drag strut of the landing gear. For lubrication of the main landing gear refer to Chapter 14.

Main Gear Wheels, Tires and Tubes

Two wheels are used on each main gear. Each wheel is composed of two separate magnesium castings which are bolted together. Each wheel half is individually balanced and no mating of wheel halves in any particular position is required. Two tapered roller bearing cones are used in each wheel assembly to reduce rolling friction and carry the loads. A felt grease retainer is provided on the inner hub and a cap on the outer hub to prevent loss of grease and entry of dirt. An aluminum internal gear drive ring is bolted to the inboard wheel half of each wheel and the steel brake disc is free of float laterally on this ring, which causes it to rotate with the wheel. When braking pressure is applied the resulting torque is transmitted to the wheel through the teeth of the drive ring. For lubrication of bearing cones, refer to Chapter 14. The tires used on the main gear wheels are low pressure, 10 ply rating, nylon 12.50 X 16 with matching tubes. Tires should, if practical have the same tread design and a similar amount of wear which will tend to equalize torque loads encountered during application of brakes and reduce likelihood of skidding. If one oversize tire must be used in a pair it should be mounted on the outboard wheel. For main gear tire pressure, refer to maintenance notes section this Chapter.

Main Gear Brakes (See figure 30)

Each of the four main wheels, is provided with brakes. Each brake assembly consists essentially of three hydraulic cylinders acting in a line perpendicular to the brake disc. Each cylinder transmits its pressure to a moulded composition button, bearing against the outer surface of the brake disc. This pressure is resisted by another similar button mounted on the face of the brake housing casting. The resultant action is a squeezing action on the brake disc, which turns with the wheel but due to its gear drive attachment is free to float within limits perpendicular to the plane of the wheel.

The piston incorporates a self-adjusting feature to compensate for wear on the brake buttons, and simultaneously provides for consistant clearance between the brake buttons and the brake disc upon release of the brakes. This same feature provides for an external visual indication of the extent of wear apparent at all times on the brake buttons.

Brake lining wear is indicated by the position of the end of the self adjusting pin in relation to the nut surrounding it. Need for lining replacement shall be determined as follows and all linings in a brake shall be replaced at the same time.

1. See Series 15-3 for service tolerances on linings and discs.

2. Brake linings need not be replaced due to small chipped sections on the outside diameter nor because of small heat checks in the friction surfaces. However, if a lining is actually broken so that large pieces, have become separated from the reinforcing screen or if the chipped pieces or heat cracks extend in from the edge past the lining step shoulder, it is cause for replacing the entire set of linings.

3. At any time a used brake lining is removed for any reason but is to be reinstalled, it should be put back in the original position to obtain uniform contact on the disc.

4. When new linings are installed in contact with a worn disc the sharp edges of the new lining must be beveled to match the existing wear indentation in the disc.

5. "Heat Checking" appears as short radial cracks over the braking surfaces of the brake discs. This is a normal condition which is not cause for replacing a disc so long as the cracks do not extend to within 1/4 inch of either edge of the disc nor the crack exceeds 1 1/4 inch in length.

NOTE: The 202A brake assembly is the same as 404 except that the dust shield which encloses the area inside of the brake disc is not used on the 404. However if a 202A assembly is being installed on a 404, the shield will be left on and it will fit satisfactorily.

NOSE LANDING GEAR (See figure 18).

The nose landing gear consists of a single retractable unit operating from a well built into the underside of the nose section of the fuselage. It is hydraulically operated and retracts forward and upward into the wheel well. The gear assembly consists of an air-oil shock strut, two-piece jointed drag strut, steering cylinder, and a wheel assembly consisting of wheel, tire and tube. The upper trunnion of this gear assembly is an integral part of the shock strut, and is mounted and pivots in fittings which are built into the structure of the nose of the fuselage within the wheel well. The drag strut is attached to a fitting integral with the lower portion of the shock strut cylinder, and to another fitting built into the wheel well. Lock linkage is arranged between the crank shaft at the top of the shock strut and the folding point of the drag strut. The hydraulic actuating cylinder for the nose gear is anchored to a fitting built into the wheel well, and during retraction or extension applies its force to the crank pin on the crankshaft which in turn operates the lockpin. The lower portion of the shock strut terminates in a fork with a removable axle for the wheel assembly. Fittings integral with the trunnion arms are provided for attachment of the door operating linkage. The nose gear is equipped with a separate nose gear shimmy damper system which reduces or eliminates nose wheel shimmy.

The nose gear lock switch is mounted on the lock strut forward link and the plunger is actuated by the end of the lock pin as specified in "Nose Gear Drag Strut And Lock Linkage". The scissor switch is attached to the upper scissor torque arm and actuated by a lever attached to the shock strut. The position switch is attached to the airplane structure and actuated by a lever attached to the upper drag strut. Provisions are made in the nose gear fork assembly for attaching a removable jack pad and fork retainer, which are used in jacking the nose gear, refer to Jacking For Servicing Nose Gear Wheel, Chapter 1. For lubrication of the nose landing gear, refer to Chapter 14.

The nose gear, under high fluid flow conditions, may have a tendency at times to go through a one-cycle bounce before the downlock mechanism engages. This condition will not indicate any malfunctioning of the unit.

Nose Gear Doors And Linkage (See figure 32).

The nose wheel well in the lower surface of the nose of the fuselage is covered by doors which are to a large degree similar to those used on the main gear wheel wells.

The smaller, aft section doors are actuated by direct rod connection to the gear proper, and remain open when the gear is extended. The two forward doors are split down the center line of the fuselage and are hinged along their upper edges. The actuating linkage provides for the doors opening for the passage of the wheel and fork, closing after passage of the wheel in either direction. This linkage is somewhat simpler. A pair of take-off points is located on the trunnion which occupies positions in the same vertical plane for both extended and retracted positions of the gear, but differing as to horizontal plane for the two extreme positions. From these points, a pair of fore and aft push-pull rods transmits the motion to bellcranks at the aft end of the doors. The secondary arm of this bellcrank is connected to the door with a link which has a swiveling attachment at the door. A cable connects the first, or aft bellcrank on each door, through a parallelogram linkage to a second bellcrank at the forward end of the doors, and from this bellcrank, by link to the door itself. This linkage also has provision for declutching the mechanism to open the forward doors for access to the wheel well.

Nose Gear Shock Strut.

The nose gear shock strut is very similar in design to and operates in the same manner as the main gear. There is a quick release pin at the torque arms, which, when removed allows the nose wheel to rotate 360 degrees. This pin must be removed whenever the plane is being towed. There is a towing attachment provided at the base of shock strut. Refer to Chapter 1 for details.

A non-swivel lockpin is inserted through the lower steering support arm to prevent turning when jacking at the nose gear.

The shock strut is filled with hydraulic fluid level with the air valve body hole with the strut fully compressed. High pressure air valve cores are used in the shock strut, refer to Air Valves And Cores, Chapter 16 for description and method of releasing air in the strut. The shock strut will not require extensive servicing between overhaul periods, but periodical checks should be made for correct inflation of strut. Excessive leakage of hydraulic fluid requires replacement of the seals, as the "O" ring seals in the strut cannot be tightened.

Nose-Gear Drag Strut And Lock Linkage. (See figure 34).

The nose gear drag strut assembly is a two piece, center-hinging strut, running from the lower part of the shock strut cylinder to a structural attachment in the upper forward part of the nose wheel well. With the gear extended, and the lock linkage engaged, the drag strut assumes a straight line between its two points of attachment, and functions to transmit all fore and aft gear loads to the fuselage nose structure. The lock linkage is essentially a two piece folding member connecting the center hinge point of the drag strut to the crankshaft running across the trunnions at the top of the gear. When the gear is fully extended, this lock linkage assumes a straight line between the center pivot point of the drag strut and the crankshaft, and acts to stabilize the center point of the drag strut. The lock link is held in a straight line position by a spring loaded lockpin, whose extraction is effected by the initial movement of the hydraulic cylinder acting on the crank pin of the crankshaft.

Nose Gear Drag Strut And Lock Linkage (Cont.).

A tension bungee attached between the upper drag strut and the forward end of the lock linkage functions to straighten the lock linkage when the gear reaches full travel in either extended or retracted position. A torsion spring is attached to, and coiled around the crankshaft and functions to straighten the lock linkage and permit the lock pin to engage. A manually operated emergency up-lock release mechanism, actuates the lock linkage to permit emergency free fall of the gear, refer to Emergency Up-Lock Release System for further deacription.

Provisions have been made in the gear lock linkage members for ground safety lock pins, which when inserted prevent accidental retraction of the gear while the airplane is on the ground, refer to Landing Gear Lock Pins Chapter 1 for further description and use. A lock switch is mounted on the forward part of the lock linkage and is actuated by movement of the lockpin. For lubrication of the nose gear lock linkage refer to Chapter 14.

Nose Wheel Brake (See Figure 4).

A nose wheel brake is installed in the wheel well at station 142 on the center line of the airplane, and its function is to stop the spinning motion of the nose wheel when it is retracted after take-off. The brake consists of a steel pad that extends into the wheel well at a point tangent to the position of the nose wheel in its retracted position. Pressure of the tire against this pad causes a braking action on the tire tread and stops the spinning wheel as soon as the gear is retracted. Pressure of the tire against the pad is resisted by a tension spring. Access to the brake is through the nose wheel well.

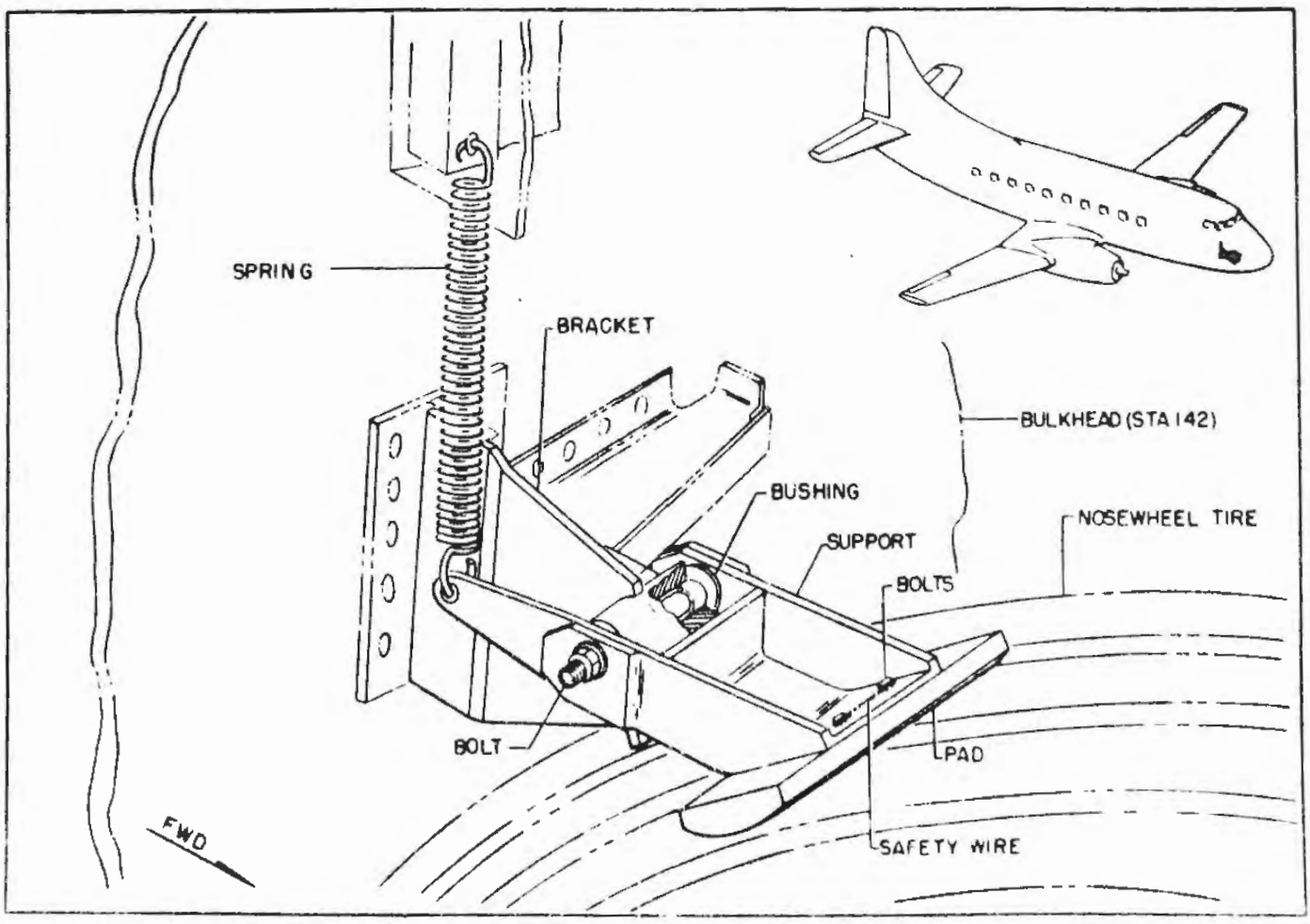


Figure 4. Nose Wheel Brake

Nose Gear Wheel, Tire And Tube.

The nose wheel consists of two separ[illegible]gnesium castings which are bolted together. Each half is individually balanced and no mating of wheel halves in any particular position is necessary. Two tapered roller bearing cones are used to reduce rolling friction and carry the loads. Felt grease seals and caps are provided to prevent loss of grease and entry of dirt. For lubrication of the bearing cones refer to Chapter 14. The tire used on the nose wheel is a low pressure, 10 ply 9:50 X 16, with matching tube. A straight stripe of yellow paint, approximately 1/2 inch wide is applied across a portion of the wheel rim and onto the tire as a reference mark to aid in detecting tire slippage. This mark shall be maintained plainly visible by repainting when necessary. Tire slippage in excess of 1/2 inch shall be cause for tire replacement. The nose wheel tire pressure is 69 psi.

Nose Gear Torque Links (See figure 18).

The nose gear torque links consist of an upper and lower torque link which are attached at the aft end by a quick disconnect pin. The torque links are disconnected any time the airplane is towed or whenever routine maintenance is being performed. The holes in the respective torque link are bushed and during service can loosen up and get lost. A check should be made whenever the torque links are disconnected or connected to determine that these bushings are in place and tight. If a bushing is loose or missing, corrective action must be taken before the airplane is released. If this is not done excessive nose wheel vibration will occur during take off and landing.

Nose Gear Viewing Window.

A viewing window located in the pressure panel below the pilots' floor provides for a visual check of the nos. landing gear to determine if the lock pin is fully engaged. An access hole with a removable rubber plug is provided in the viewing window, through which a probe bar may be inserted to push against the jury strut and straighten it out, thus allowing the lock pin to engage. The plug is attached to the airplane structure by a lanyard to prevent its loss.

Access to the viewing window and plug is gained by opening the Cockpit Step Access Door No. 105 located on the bottom step riser to the pilots' compartment.

CAUTION

Determine that the rubber plug is securely installed in viewing window before each flight, to permit pressurization in flight.

*Airplanes number 401, 402, 411 and up have the installation. Airplanes 403 through 410 will have this installation when modified.

EMERGENCY UP-LOCK RELEASE SYSTEM (See figure 36).

The emergency up-lock release system consists of a cable extending from a handle located below the floor of the pilots' compartment, forward to the nose gear up lock release mechanism and then aft through the fuselage and out through either wing to the main gear up lock release mechanism.

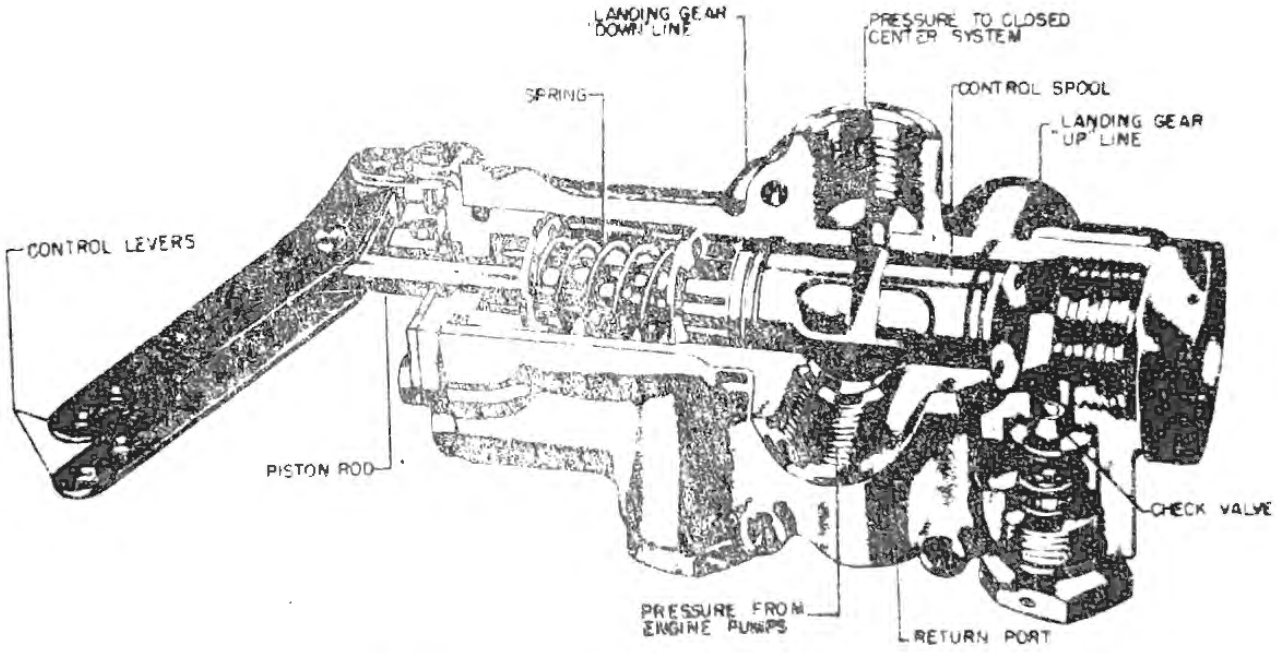
When the emergency release is pulled, the cable forces the tripper arms on the emergency release mechanisms on all three gears down against the studs on the lockpin link assemblies, pulling the lockpins and allowing the gears to drop. The tripper arms are spring loaded so that they will return to neutral when the emergency up-lock release handle is released. Access to the emergency release handle is through a hinged door on the pilot's compartment step, and is identified with a placard marked "EMERGENCY GEAR EXTENSION DO NOT LOWE R ABOVE 130 M.P.H.

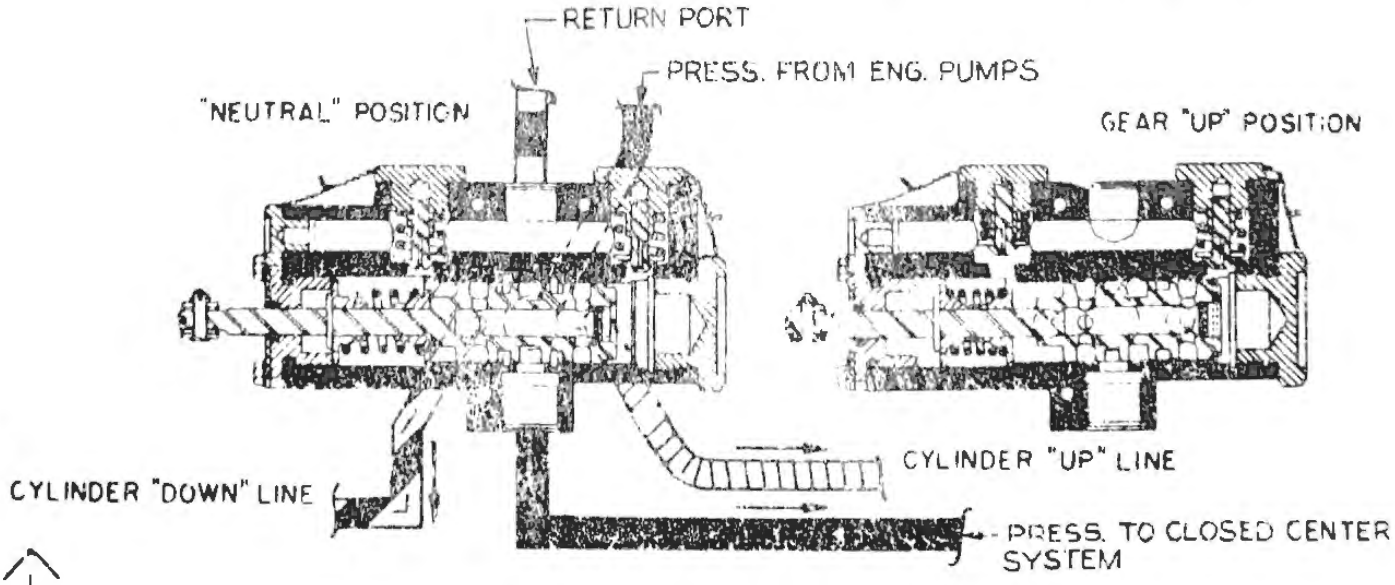
Cabin pressure seals are installed around the emergency up-lock cables where they go into the pressure area, refer to Chapter 8 for installation of seals.

Landing Gear Control Valve (See Figure 2)

The landing gear control valve is installed in the open center hydraulic system and is attached to a bracket mounted on the structure below the pilot's floor on the left hand side of the airplane. It is accessible through the nose wheel well.

The valve is a automatic recentering slide type, directional unit and is operated through mechanical linkage by the landing gear lever on the pilot's pedestal. Hydraulic pressure is directed into the nose and main gear actuating cylinder by this valve. When the valve is in neutral position, both cylinder ports are open to the return line and fluid from the pumps is free to pass through the valve to the closed center system pressure regulator.





Main Landing Gear Actuating Cylinder. (See figure 6).

Two actuating cylinders, one for the left main gear and one for the right main gear, convert hydraulic pressure into mechanical energy for operation of the main landing gears.

The cylinders are double acting, in that hydraulic pressure is used to extend and retract the piston. For cylinder extended and retracted length and pressure requirements refer to 15-3 of this chapter.

The (cylinder end) of each actuating cylinder is attached to a bellcrank adjacent to the structure attachment of the drag strut damper cylinder (air-oil drag strut on Figure 46). When the main gear drag strut elongates (moves aft) during brake application or other such load, the drag strut damper cylinder linkage rotates the bellcrank moving the actuating cylinder attach point back to prevent damage to the cylinder. See "Main Gear Oleo Drag Strut" Series 15-1 of this Chapter for further details.

Hydraulic pressure directed into the top port, extends the piston rod (gear down) and when directed into the bottom port, retracts the piston rod (gear up). A snubbing device in the piston provides a cushioning effect near the retracted end of the stroke and an enlarged section of the piston rod provides cushioning when it enters the (rod end) cylinder head, in the extended position.

Cylinders can be bled after any system connections have been made by means of the bleeder plug provided at each end of the cylinder. The rod end (up line) must be bled with the cylinder in the extended position (gear down and ground locked).

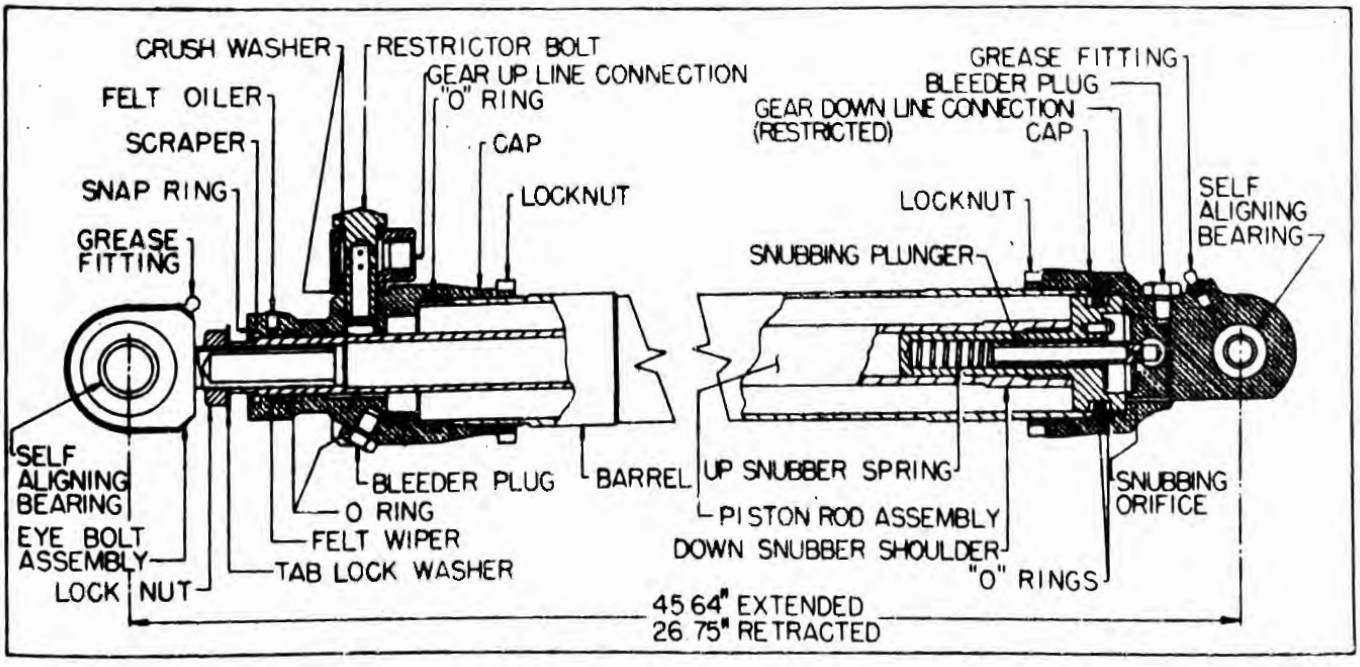


Figure 6. Main Landing Gear Actuating Cylinder

NOSE WHEEL STEERING AND SHIMMY DAMPING-GENERAL. (See figure 22).

The nose wheel is steered through various degrees of right or left turns by a self-centering steering mechanism, powered by a hydraulic cylinder. The mechanism consists of the steer valve, sequence valve, actuating cylinder, two check valves, and the various mechanical links.

The steering control wheel is mounted on the pilot's console and transmits its torque through a gear box to an arm on the side of the gear box. A push-pull rod then transmits the motion to a floating bellcrank under the pilot's floor. Linkage from the bellcrank ties in with the steer valve and the follow-up mechanism.

A separate nose gear shimmy damper system is provided. Refer to Page 37 for further information on this system.

Nose Wheel Steering Operation (See figure 22).

In operation, the control wheel is turned to any point, right or left, 0 to 110 degrees, resulting in a 0 to 59½ degree turn of the nose wheel. This motion initially moves the steer valve to a greater or lesser degree, and the resultant flow of hydraulic fluid under pressure to the actuating cylinder results in nose wheel movement in the same direction. Immediately after the nose wheel begins its turn, the follow up linkage starts to return the steer valve to a neutral or off position. The actuation of the steering control, and the motion of the follow-up linkage is almost simultaneous, resulting in a minimum lapse of time between turn of the steering wheel and the movement of the nose wheel.

Hydraulic pressure to the steering cylinder is routed through a pressure line from the closed center system to a shut-off valve in the nose wheel well. With the nose gear in retracted position, the drag link acts on the shut-off valve so that the pressure port is closed to system pressure. This is a precautionary measure to prevent damage to the entire mechanism in case of inadvertent operation of the steering wheel with the gear retracted.

Shimmy of the nose gear during landing, take-off and taxiing is prevented by the design of the steer control valve, actuating cylinder, and the friction collar mounted on the nose gear.

Nose Wheel Steering Check Valves (See figure 22).

There are two check valves installed in the nose wheel steering hydraulic circuit. A 1500 psi check valve is installed in the pressure line between the shut-off valve, and the steer control valve. It permits free flow into the steer control valve and steer circuit, but checks reverse flow. The purpose of this valve is to prevent loss of pressure in the pressure line of the steer circuit, should there be a loss of closed center system pressure.

A 3000 psi check valve is installed in the steer return line. It permits free flow into the main return line, but checks reverse flow. The purpose of this valve is to protect the steer shut-off valve from pressure surge in the return line. It is important that these valves be installed in their respective circuit with free flow in the direction as indicated by the arrow on the valve body.

These check valves are located in the nose wheel well and are accessible through the forward nose gear doors.

Nose Wheel Steering Cylinder (See figure 42)

The nose wheel steer actuating cylinder is mounted on the upper and lower supports of the steering mechanism on the oleo strut of the nose gear. It is the actuating unit of the steering circuit. The cylinder is double-acting in that the hydraulic pressure is used to extend and retract the piston. The cylinder is designed for an operating pressure of 1500 psi. A fluid port at each end of the cylinder provides connections for the operating lines of the steering control valve. Both ends of the piston rod are external, with the forward end unattached and the aft end attached to the upper lever of the steering mechanism on the gears. A wiper ring in the gland end of cylinder keeps the piston rod free of dust particles. An adjustable end fitting screws into the attachable end of the rod. The length of the rod can be adjusted by this fitting to equalize the degree of travel in either direction. "O" ring packings are installed in the piston, and in the ends of the cylinder to prevent internal and external leakage. The cylinder should be lubricated with hydraulic fluid at regular servicing intervals by means of oiler fittings installed on the cylinder. An orifice is drilled through the piston to allow a restricted flow of fluid from one side of the piston to the other thus effecting a better resistance to shimmy upon deflection of the nose gear.

Nose Wheel Steering Control Valve (See figure 10)

The nose wheel steering control valve is located in the outboard left side of the nose wheel well below the pilots' floor, and is accessible through the nose wheel well side pressure panel.

The body of the valve houses a piston, two springs, spring retainers, spring guide, spring tension nut and a snap ring. A housing screws on the end of the valve and a cap screws on the end of the housing.

The valve is a slide-type four-way metering valve. Hydraulic pressure from the closed center system is directed into the steer actuating cylinder, and return flow is directed to the main system return by the valve. In neutral position both of the cylinder ports are connected to the pressure port of the valve by a small orifice in each cylinder port. This provides full system pressure (1500 psi) on each side of the steer actuating cylinder, thus reducing shimmy of the nose wheel in high speed steering operation. The other orifices in each cylinder port are so arranged that movement of the piston in either direction provides the increased volume of fluid in the cylinder ports necessary for low

Nose Wheel Steering Control Valve (Cont.).

speed steering operation. Double springs in the valve housing provides the pilot with the "feel" that is necessary for smooth steering. Internal leakage is kept to a minimum by the precise fit of the spool in the valve.

CAUTION

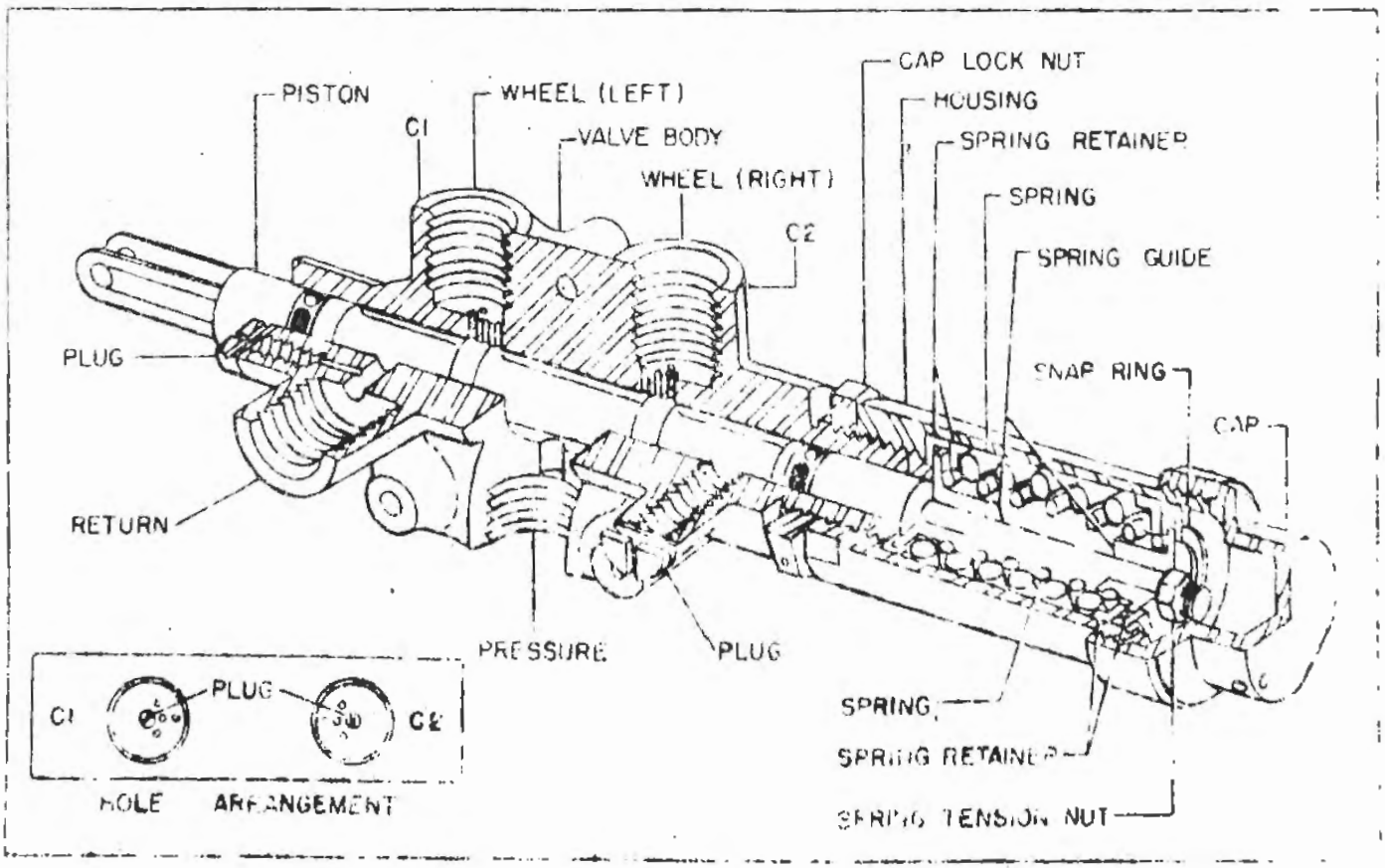
The spool of the control valve is a lap fit, and is not interchangeable with the other valves having the same part number.

The control valve is actuated through a direct mechanical linkage from the steering wheel located on the pilot's console.

Nose Wheel Steering Shut-Off Valve. (See Figure 22).

The shut-off valve for the nose wheel steering circuit is a two-position valve which functions in sequence with the nose gear operation. It is installed in the pressure line of the closed center system and is located just forward of the nose gear drag strut in the nose wheel well. The 1500 psi pressure line, main return line, and pressure line of the steering control valve connect to the three ports of this valve.

A plunger extends from the end of the valve and is actuated by the drag strut of the gear. When the nose gear is extended the plunger is depressed, thereby closing the return port of the valve and opening the pressure port. This releases pressure to the steering control valve and, through a tee connection, to the nose gear shimmy damper system. Retraction of the gear allows the plunger to open and return to neutral position. This closes the pressure port and opens the return port. With the shut-off valve in closed position, with the nose gear retracted, the nose wheel steering circuit is not open to hydraulic pressure. Travel of the plunger only 5/16 inch in either direction opens or closes the valve to pressure. To adjust the valve, loosen the locknut on plunger end and adjust plunger to 5/16 inch travel into valve when nose gear is in down position. After adjustment the locknut must be tightened.



NOSE GEAR SHIMMY DAMPER SYSTEM
(See figure 23)

A hydraulically-operated nose gear shimmy damper system is provided in the airplane and consists of a friction collar, a pressure regulator valve, check valve, tubing and flexible hose. The system is provided to eliminate nose gear shimmy tendencies resulting from the accumulation of manufacturing and wear tolerances in the nose gear. The friction collar is mounted below the nose gear steer collar and consists of a cylinder and piston. The pressure regulator valve is mounted in the nose wheel well just forward of the steering shut-off valve. It serves to reduce the hydraulic pressure from 1500 psi found in the closed center system to 550 psi at the cylinder. A constant bleed occurs in the valve to permit proper operation of the system. An adjustment screw is provided on one end of the valve to permit readjustment of the pressure. A lockwire secures the adjustment screw which is set before installation.

When the steer shut-off valve is opened by lowering the nose gear, 1500 psi hydraulic pressure is admitted to the pressure regulator valve but only 550 psi is released to the friction cylinder on the nose gear. Pressure in excess of 550 psi is relieved by fluid flow from the pressure regulator valve to the return system. Pressure within the friction cylinder forces the piston against the steer collar bushing, thus creating friction which reduces or eliminates nose gear shimmy. An O-ring seal below the piston prevents leakage of hydraulic fluid.

Two index lines are scribed on the outside of the friction collar cylinder for use in adjusting the collar on the strut assembly. The lower index mark should be barely visible when the friction collar is assembled and installed or after it has been readjusted after service wear. The dimension between the scribe marks is .062". When the shoulder thickness of either the upper or lower bushing reaches a minimum thickness of $.060 \pm^{.005}_{.000}$ inch, that bushing must be replaced with a new one.

Five plugged ports are provided on the bottom side of the cylinder to permit rotation of the cylinder for adjustment purposes. The fitting is moved to a new port each time an adjustment is required. A special bolt is used to attach the friction collar to the strut. A flexible hydraulic hose connects the fixed line located on the fuselage to the fixed steel hydraulic tube located on the nose wheel.

As the nose gear is retracted the steer shut-off valve is closed thus shutting off the 1500 psi pressure to the friction collar pressure regulator valve. Excess pressure is quickly bled off internally in the pressure regulator valve, thus allowing the centering cam to return the nose wheel to its center position.

NORMAL BRAKE HYDRAULIC CIRCUIT (See figure 11).

GENERAL.

Normal brake operation on the dual wheels of the main landing gears is accomplished by means of a combined system of mechanical linkage and hydraulic pressure. The brake circuit is supplied by hydraulic pressure from the 1500 psi closed center system and consists of the following units, right and left brake valves, two normal brake manifolds, four shuttle valves, four disconnect fittings and four brake assemblies. A normal brake manifold is mounted on the lower end of the right and left gear shock strut. The manifold on the right gear routes hydraulic pressure from the right gear brake valve to the two shuttle valves, and to the two brake assemblies for the right wheels. The manifold on the left gear routes hydraulic pressure from the left gear brake valve to the two shuttle valves and the two brake assemblies for the left wheels. Hydraulic lines from the brake valves to the brake assemblies are of aluminum alloy, and stainless steel tubing. Hose assemblies are used when flexibility is required. Protective wrappings of synthetic rubber strips are applied to the flexible lines where they go through the guide rings on the landing gear scissors. Other rubber strip wrappings are applied where the flexible lines cross the transverse beam of the gear trunnion.

Normal Brake Operation (See figure 11).

Actuation of either the pilot's or co-pilot's brake pedals operates the brake control valves, through mechanical linkage opening the pressure ports of the valve to the brake operating line ports. Hydraulic pressure is then directed into the brake assemblies on each main gear, through the normal brake manifolds, shuttle valves and disconnect fittings. This pressure in the brake assemblies causes the pistons to expand. As the pistons expand the [illegible] buttons on the pistons press against the [illegible] disc, forcing it inward against the inner [illegible] buttons on the brake housing. The pistons e[illegible] until the brake disc is firmly gripped [illegible] the brake button thus stopping the rotati[illegible] wheels. When the brake pedals are released the connecting linkage actuates the brake valves to the off position. This closes the brake operating ports to pressure and opens them to the return ports so that the hydraulic fluid flows into the main return line. A tension spring behind each piston returns it to normal position.

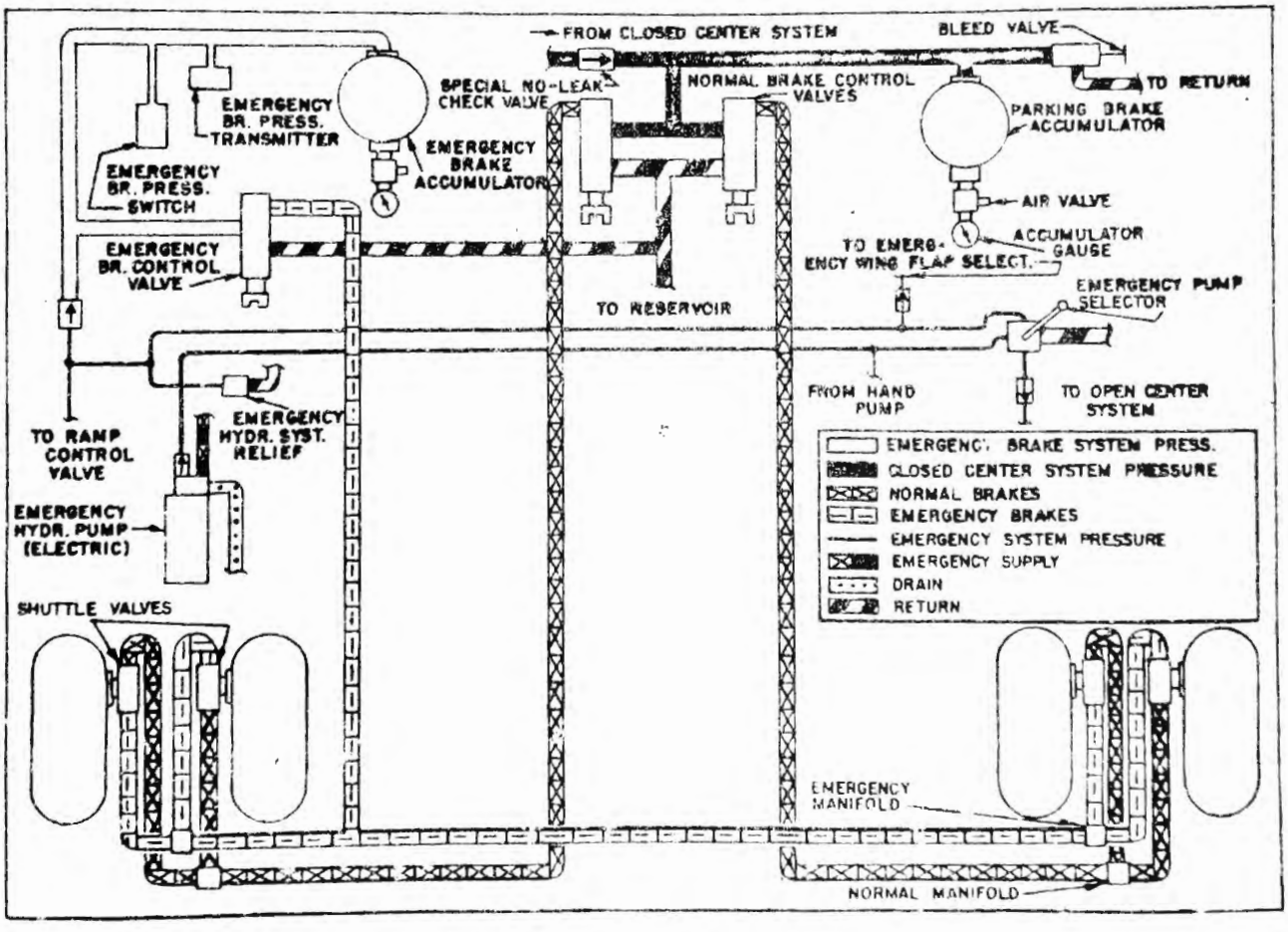


Figure 11. Normal And Emergency Hydraulic Brake Schematic

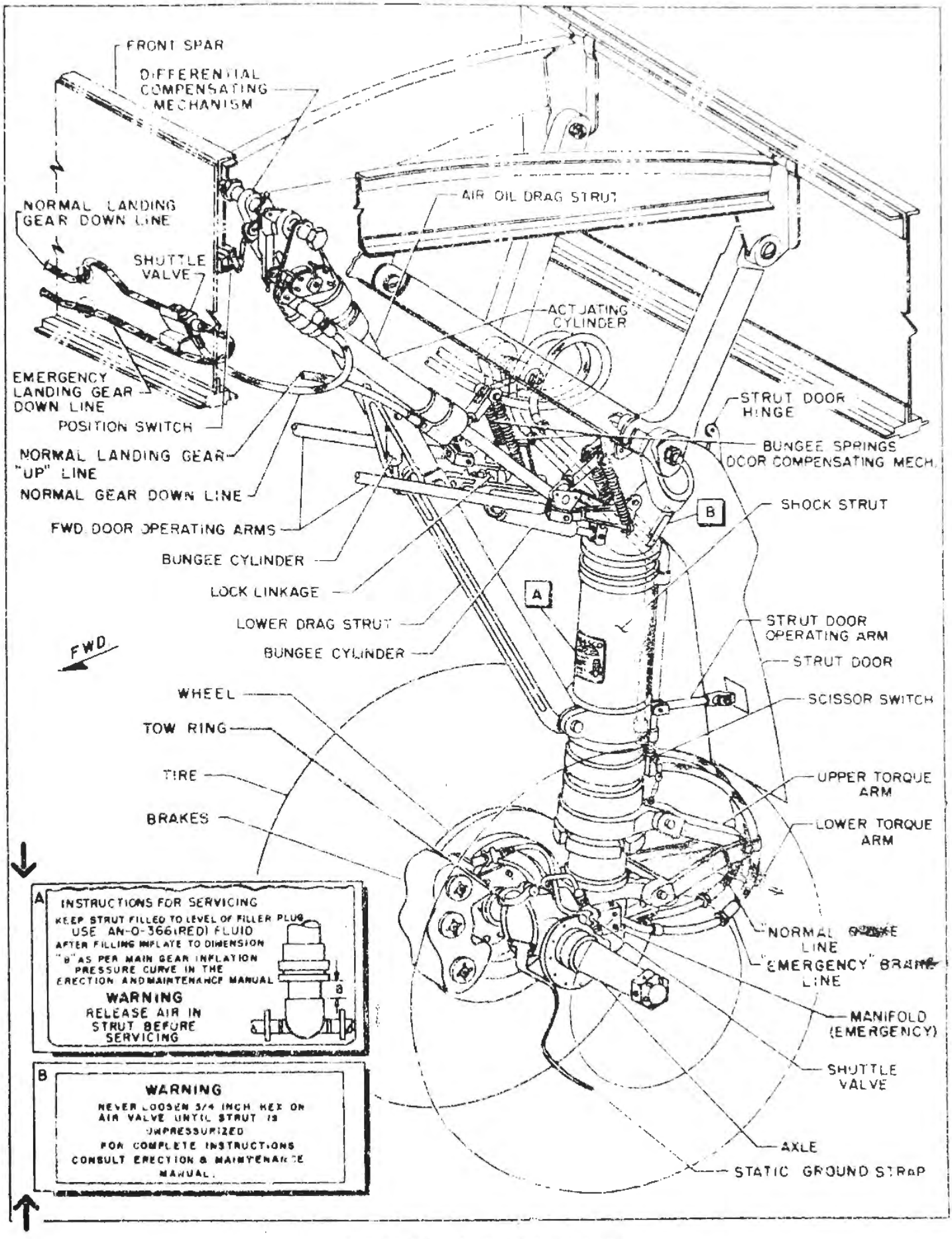


Figure 16. Main Landing Gear

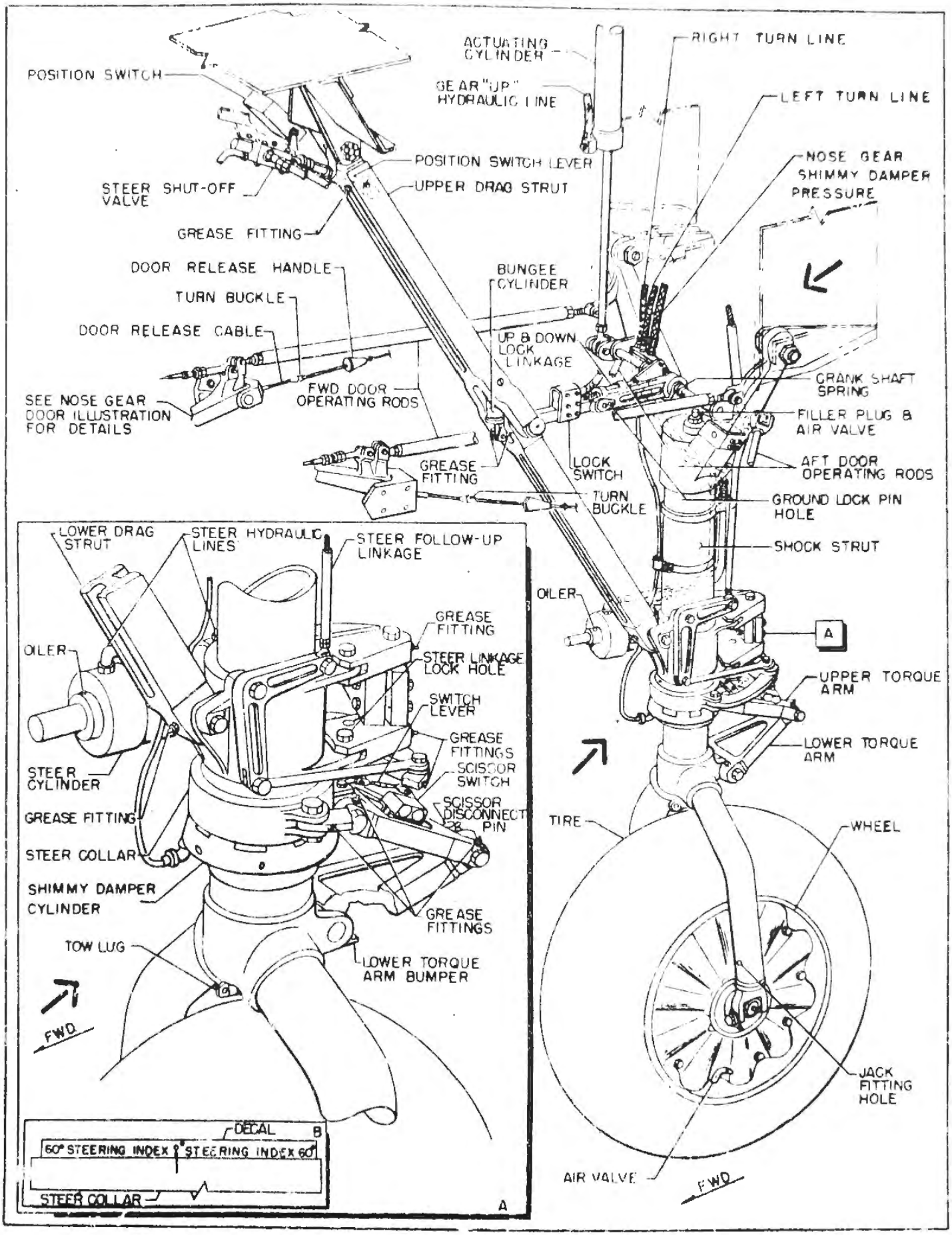


Figure 18. Nose Landing Gear

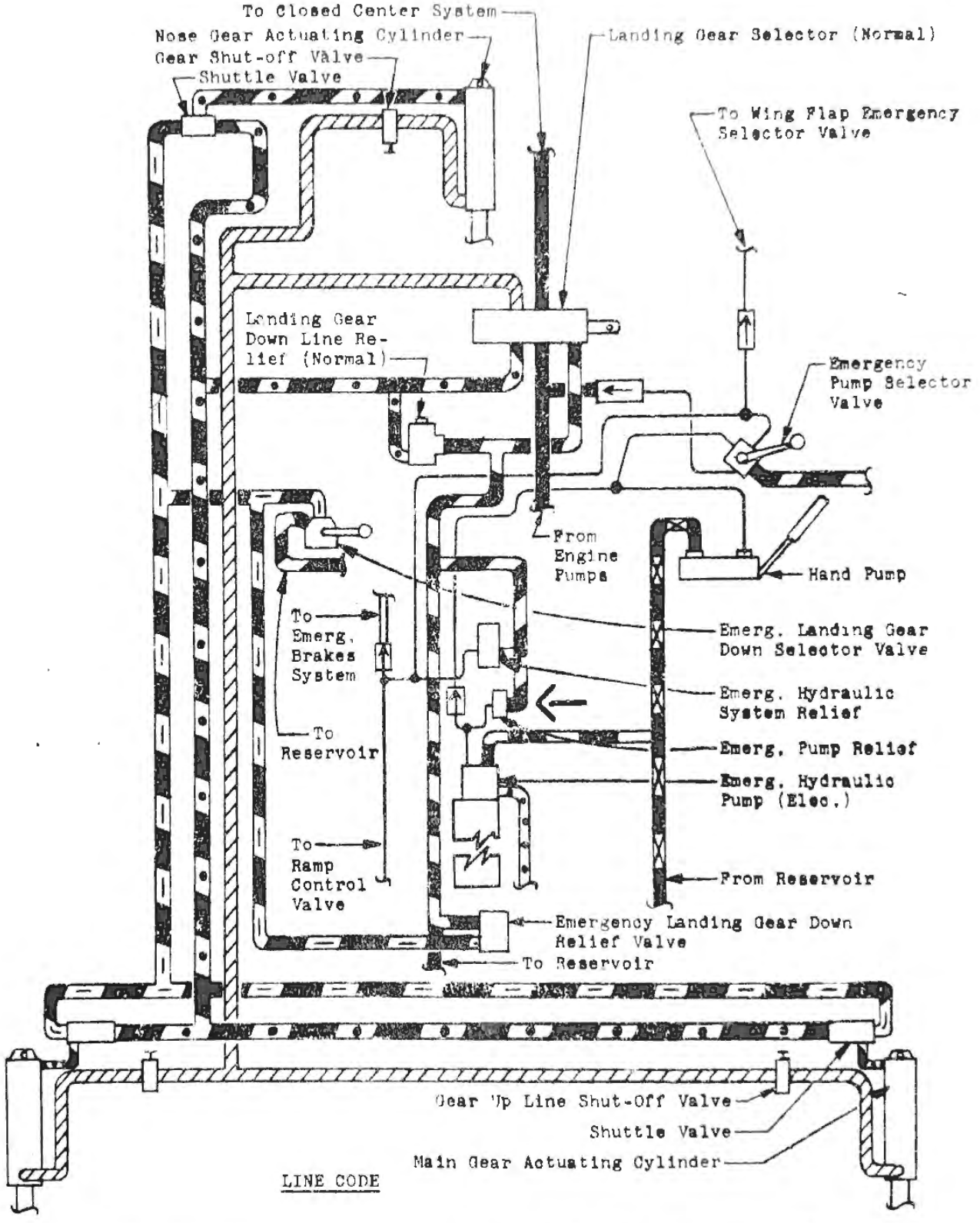


Figure 20 Landing Gear Hydraulic System Schematic

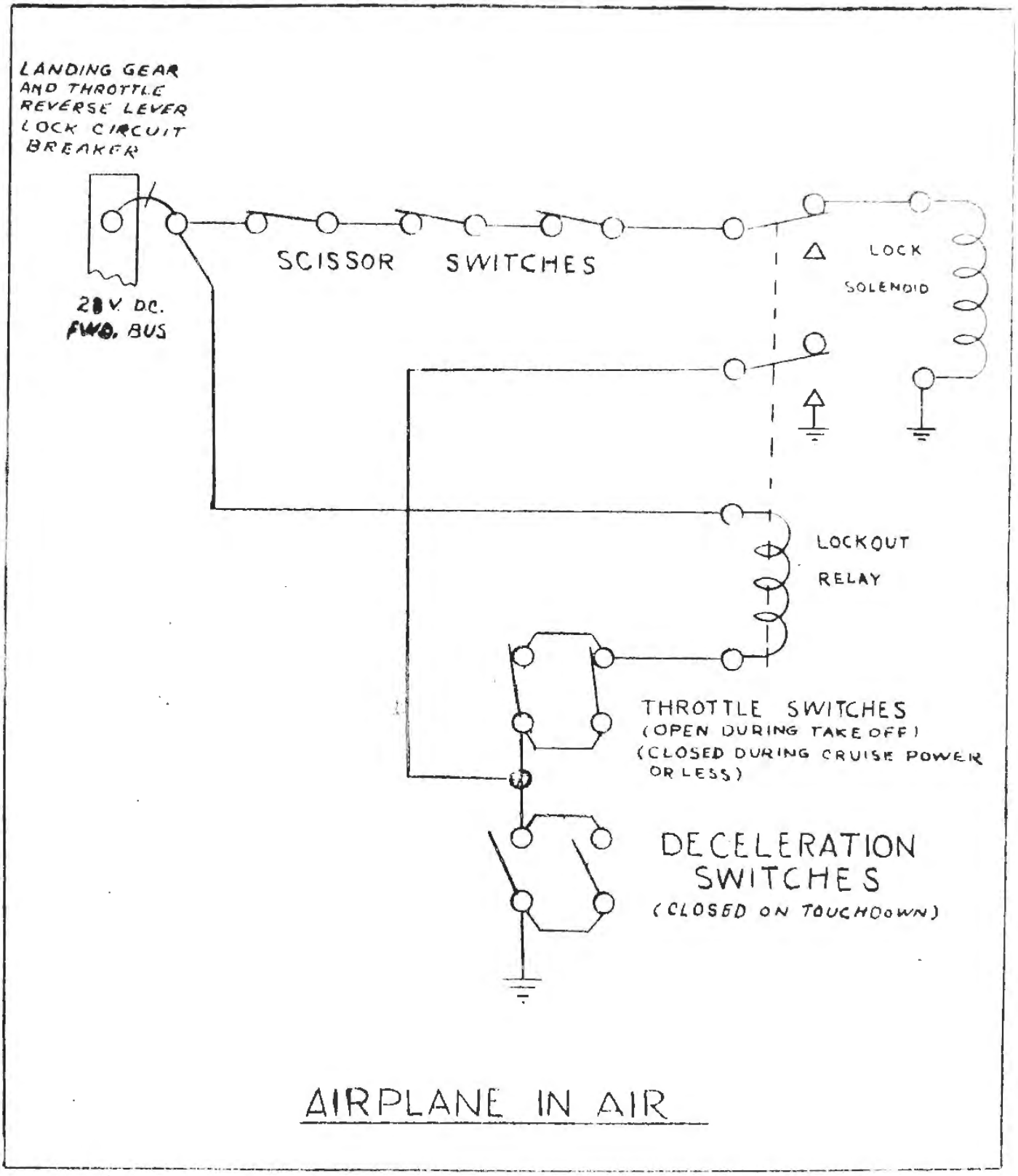


FIGURE 27: Landing Gear Lever and Reverse Throttle Lock Schematic

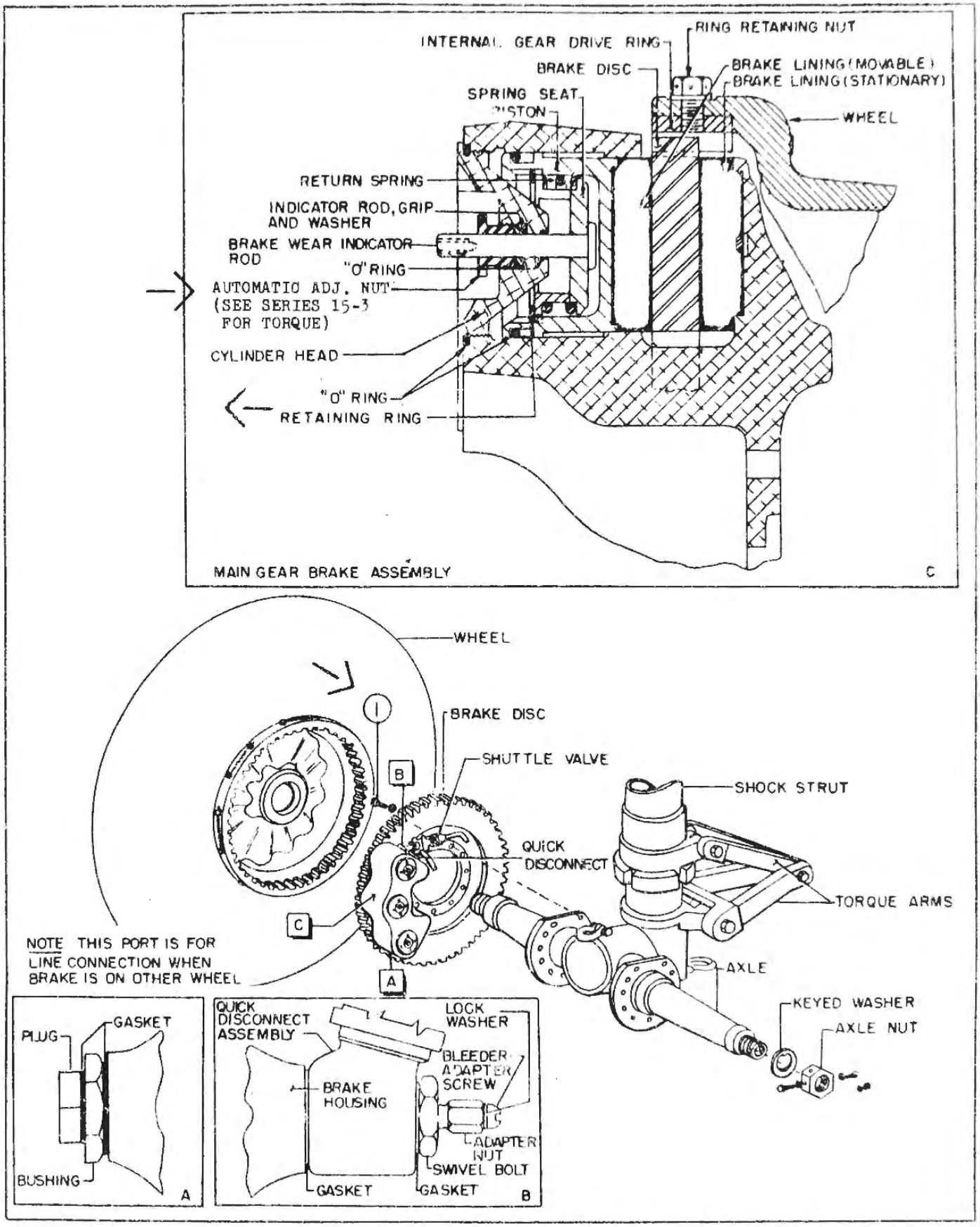


Figure 30. Main Landing Gear Wheel and Brake

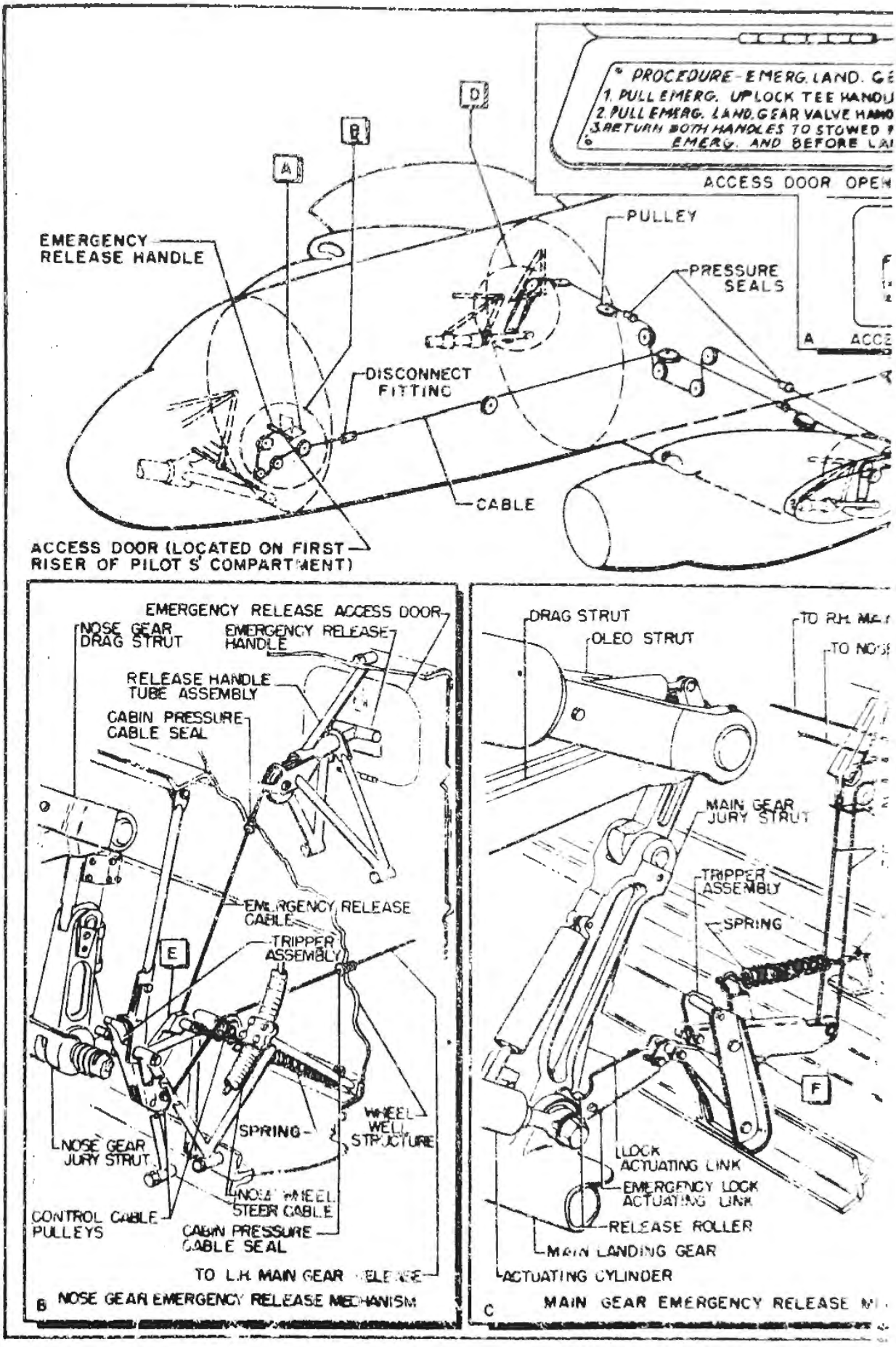
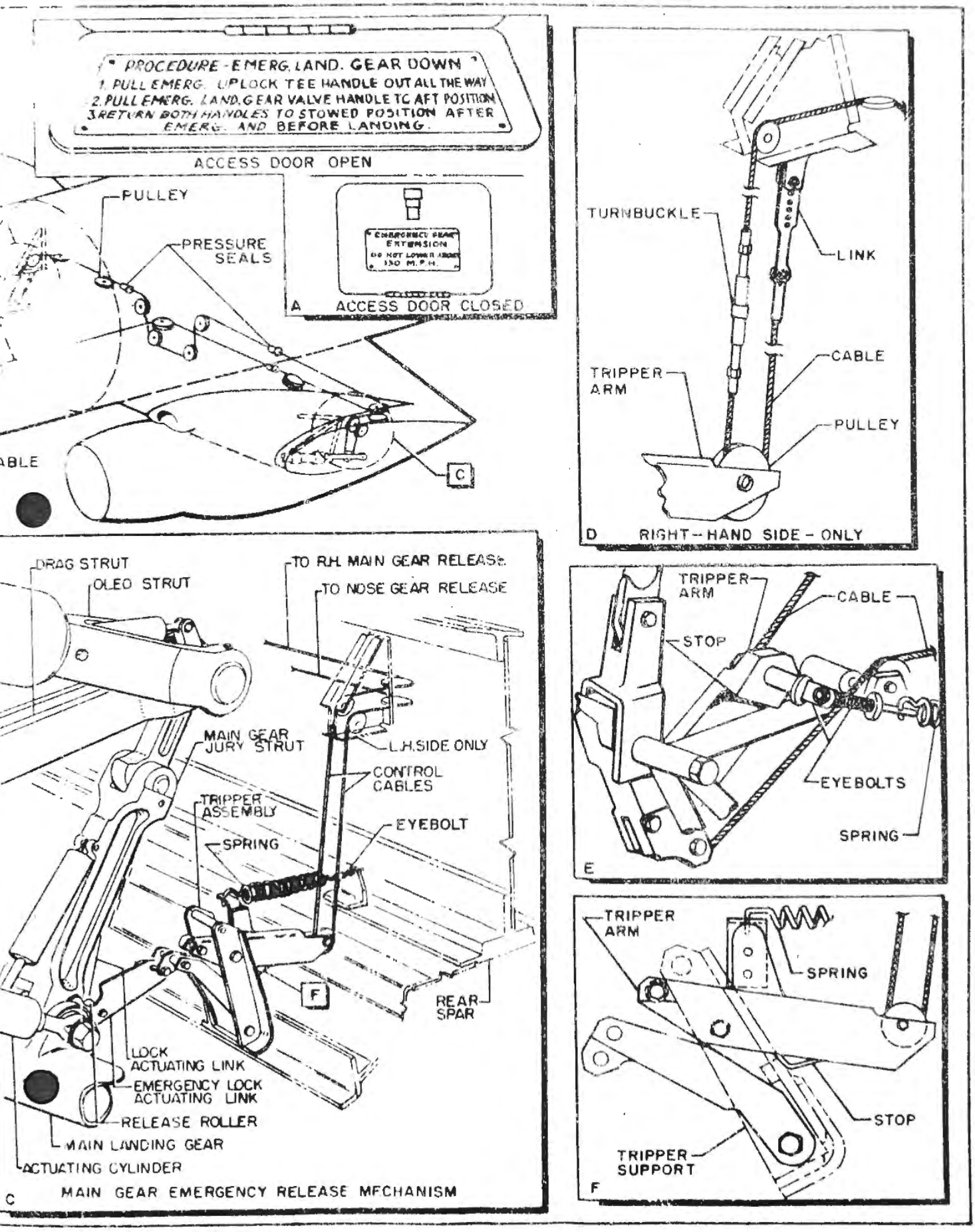


Figure 36. Emergency Up-lock Rel


" PROCEDURE - EMERG. LAND. GEAR DOWN "
1. PULL EMERG. UPLOCK TEE HANDLE OUT ALL THE WAY
2. PULL EMERG. LAND. GEAR VALVE HANDLE TO AFT POSITION
3. RETURN BOTH HANDLES TO STOWED POSITION AFTER EMERG. AND BEFORE LANDING.
ACCESS DOOR OPEN
PULLEY
PRESSURE SEALS
EMERGENCY GEAR EXTENSION
DO NOT LOWER ABOVE 130 M.P.H.
A ACCESS DOOR CLOSED
C
TURNBUCKLE
LINK
CABLE
TRIPPER ARM
PULLEY
D RIGHT-HAND SIDE - ONLY
DRAG STRUT
OLEO STRUT
TO R.H. MAIN GEAR RELEASE
TO NOSE GEAR RELEASE
MAIN GEAR JURY STRUT
L.H. SIDE ONLY
CONTROL CABLES
TRIPPER ASSEMBLY
EYEBOLT
SPRING
F
REAR SPAR
LOCK ACTUATING LINK
EMERGENCY LOCK ACTUATING LINK
RELEASE ROLLER
MAIN LANDING GEAR
ACTUATING CYLINDER
C MAIN GEAR EMERGENCY RELEASE MECHANISM
TRIPPER ARM
CABLE
STOP
EYEBOLTS
SPRING
E
TRIPPER ARM
SPRING
STOP
TRIPPER SUPPORT
F

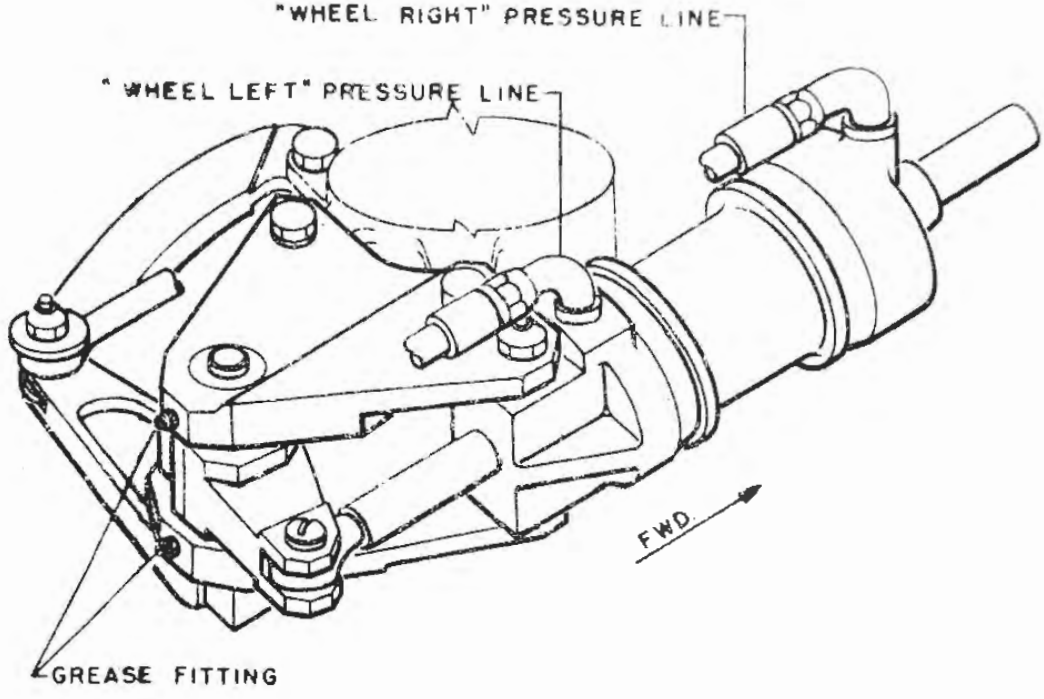
END

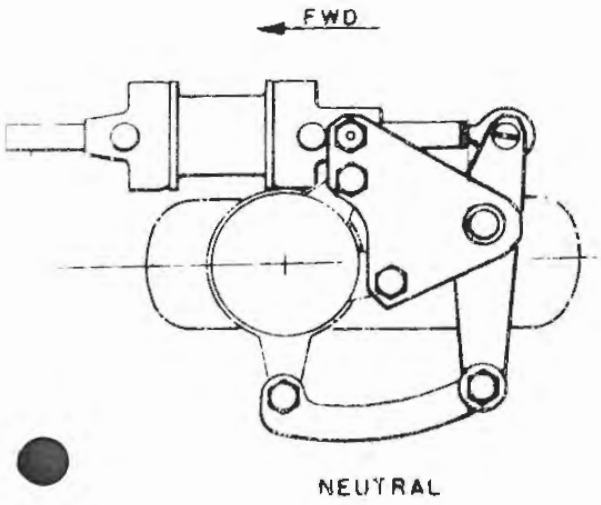
SION SHAFT

CK PIN HOLE
VER SUPPORT
LOWER LEVER

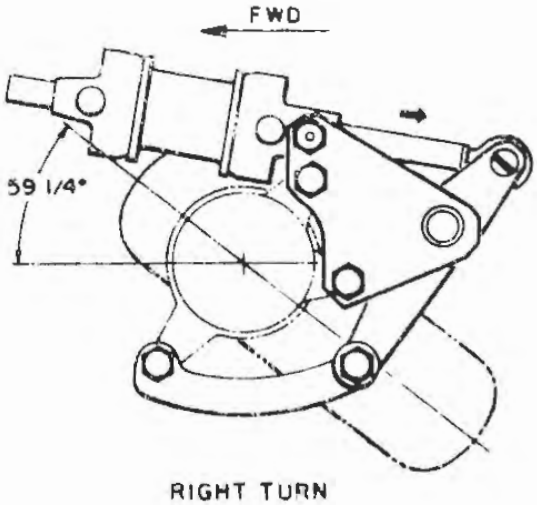
SH-PULL ROD
NOSE WHEEL STEERING
LLOW UP SYSTEM

TING





NEUTRAL



RIGHT TURN

-2. Nose Wheel Steering Cylinder

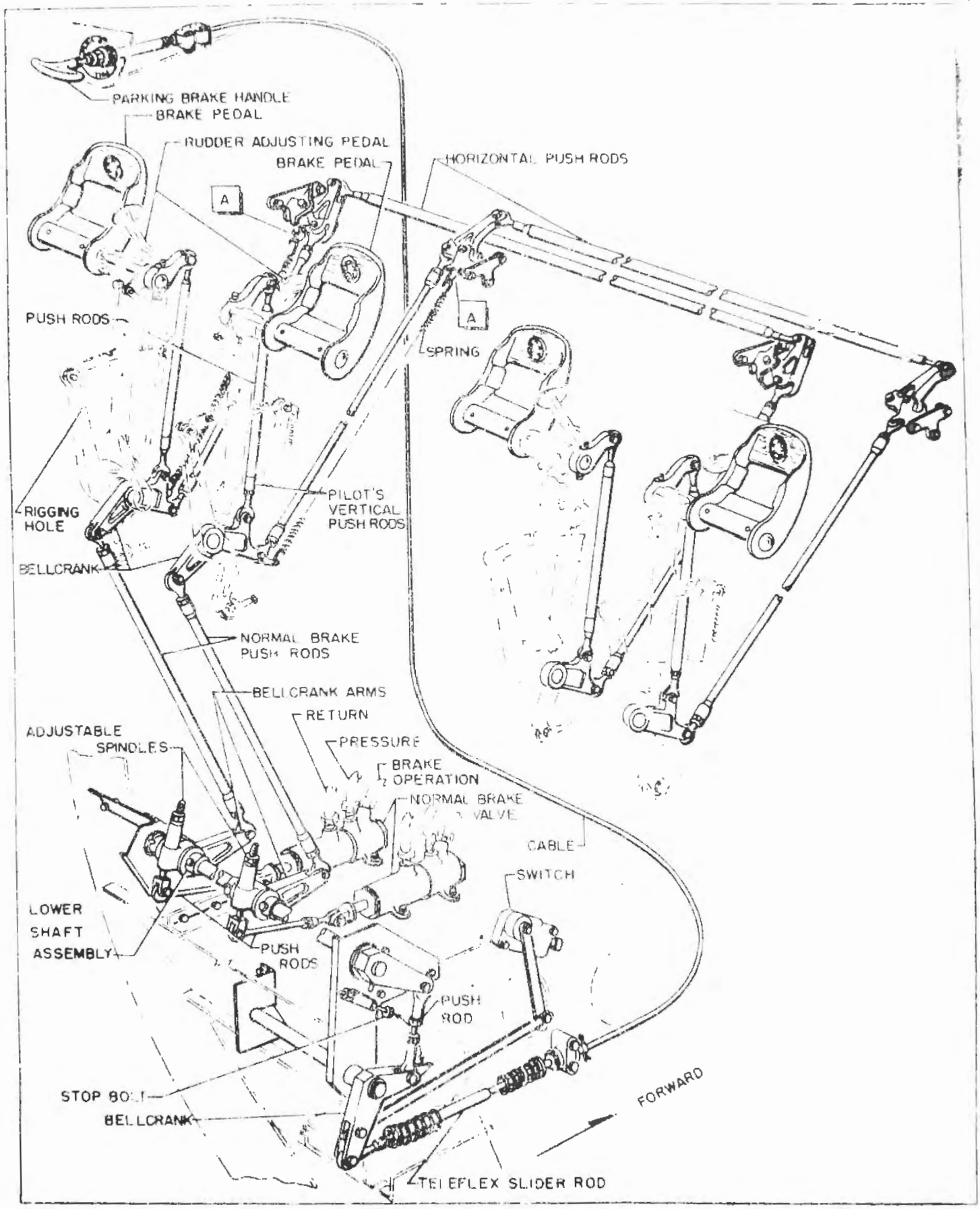


Figure 44. Parking Brake Installation

Tire Pressures

Nose Wheels	69 ½ - 2 psi
Main Wheels	60 ½ - 2 psi

After inflating a tire, determine that valve core has no leaks; then install a valve cap. A leaking valve core shall be replaced, using a new core.

Torque Values.

Main gear trunnion bolts.	100 inch-pounds
Main gear drag strut bolts.	40-60 inch-pounds.
Main gear wheel bolts	336 inch-pounds.
Brake drive ring bolts.	90 inch-pounds.
Brake indicator packing nut.	300 inch-pounds.
Brake piston cylinder head.	900 inch-pounds.
Brake bleeder screw.	35 inch-pounds.
Steering wheel nut.	70 inch-pounds.
Main gear actuating cylinder	
(a) Upper attachment bolts.	168-192 inch-pounds.
(b) Crankshaft attachment nut.	660 inch-pounds.
Nose gear actuating cylinder	
(a) Upper attachment bolts.	480-696 inch-pounds.
(b) Crankshaft attachment nut.	168 inch-pounds.

Hydraulic System Data.

Operating pressure of open-center system	3000 to 3300 psi
Operating pressure of closed-center system.	1250 - 1525 psi
Total fluid volume in system.	Refer to Chapter 16.
Type of fluid.	Specification number MIL-O-5606.

Relief Valve Settings.

Landing gear pressure relief valve.

Cracking pressure	860 psi.
Full flow at 16 gpm	950 psi.
Reseat pressure	775 psi.

Emergency landing gear down pressure relief valve.

Cracking pressure	800 psi.
Full Flow at 1.2 gpm	950 psi.
Reseat pressure	720 psi.

Landing Gear Actuating Cylinders.

Nose gear cylinder.

Retracted length	23 9/16 inches
Extended length	39 inches
Total stroke	15 7/16 inches

Main gear cylinders.

Retracted length	26 3/4 inches
Extended length	45 41/64 inches
Total stroke	18 57/64 inches

Main gear drag strut cylinder.

Retracted length	32.340 inches.
Extended length	34.215 inches.
Total stroke	1.875 inches.

Brake Pressure Settings.

Normal brake pressure	1250 ± 25 psi.
Emergency brake pressure	1250 ± 25 psi.
Parking brake pressure	875 ± 25 psi.

Accumulator Preload Air Pressure.

Main 7½ inch.	800 psi
Emergency 5 inch.	600 psi.
Parking brake 5 inch.	600 psi.

Hydraulic pressure must be relieved when replacing a unit or disconnecting a line connection in the hydraulic system. Refer to Chapter 16 for instructions.

A check must be made for leaks, after replacement of any unit in the hydraulic system. A check for air leaks at accumulator, shock strut and drag strut fittings may be found by brushing soapy water at air fittings.

Servicing Landing Gear Shock Struts.

Deflate the shock strut. Refer to Air Valves and Cores in Chapter 16 for instructions. Fill shock strut by removing air valve at top of strut and fill with hydraulic fluid, Spec.No. MIL-O-5606, until fluid is level with air valve body hole with strut fully compressed. Refer to index for inflation procedure.

Nose Gear Shimmy Damper System

The operating pressure of the nose gear shimmy damper system from the pressure regulator valve to the friction cylinder is 550 psi. The pressure regulator valve is preset to this value and relieves all pressures above the 550 psi.

Brake Linings

Wear tolerances on brake linings are as follows

100 - replace linings when indicator pin protrudes less than 1/8" from nut.

Terminal Stations - replace linings when indicator pin is flush with or recessed into nut.

Line Stations - replace linings when indicator pin is 1/8" inside nut.

Brake Discs

Brake discs shall be replaced if less than .530" width at thinnest place at time of brake lining replacement.

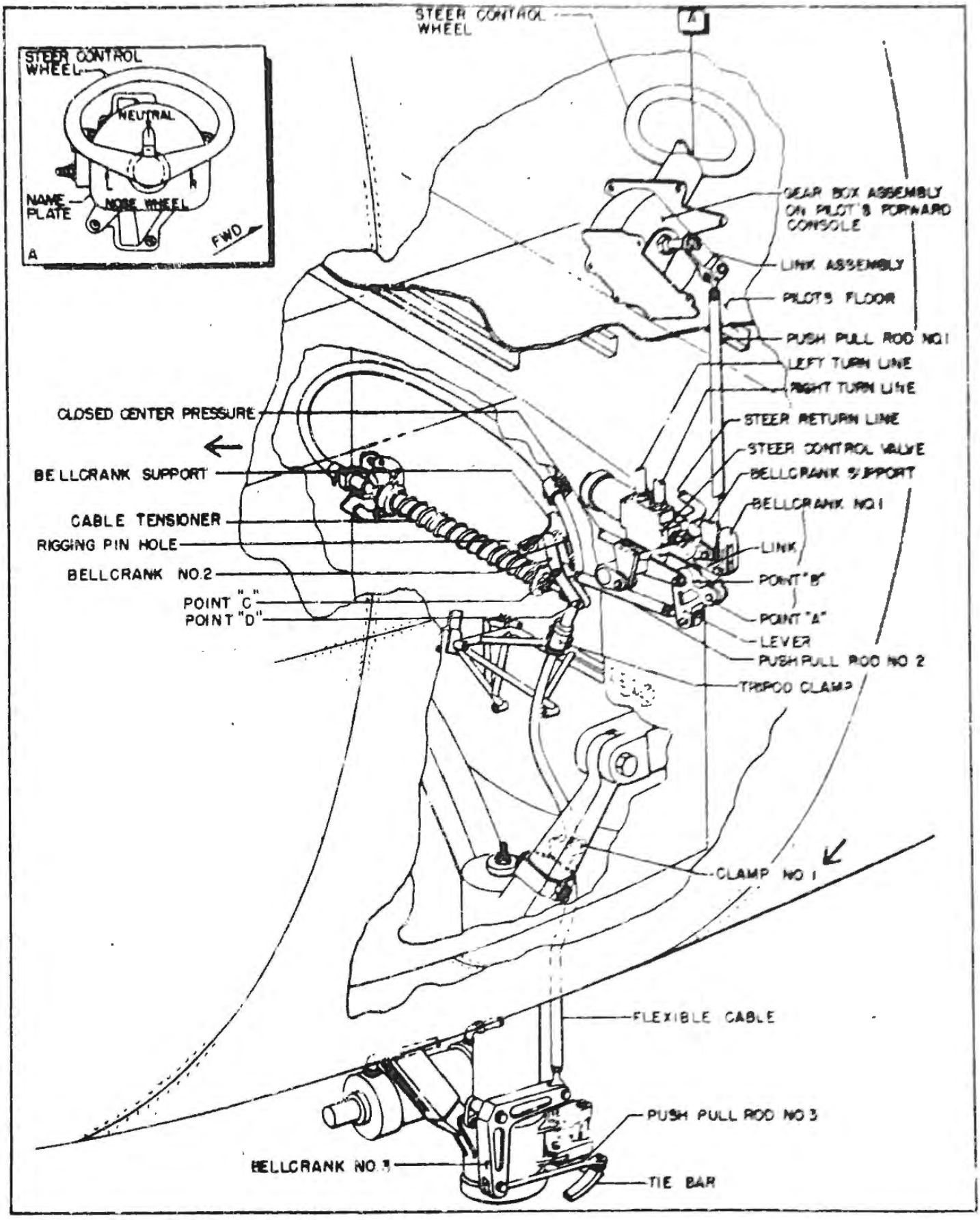
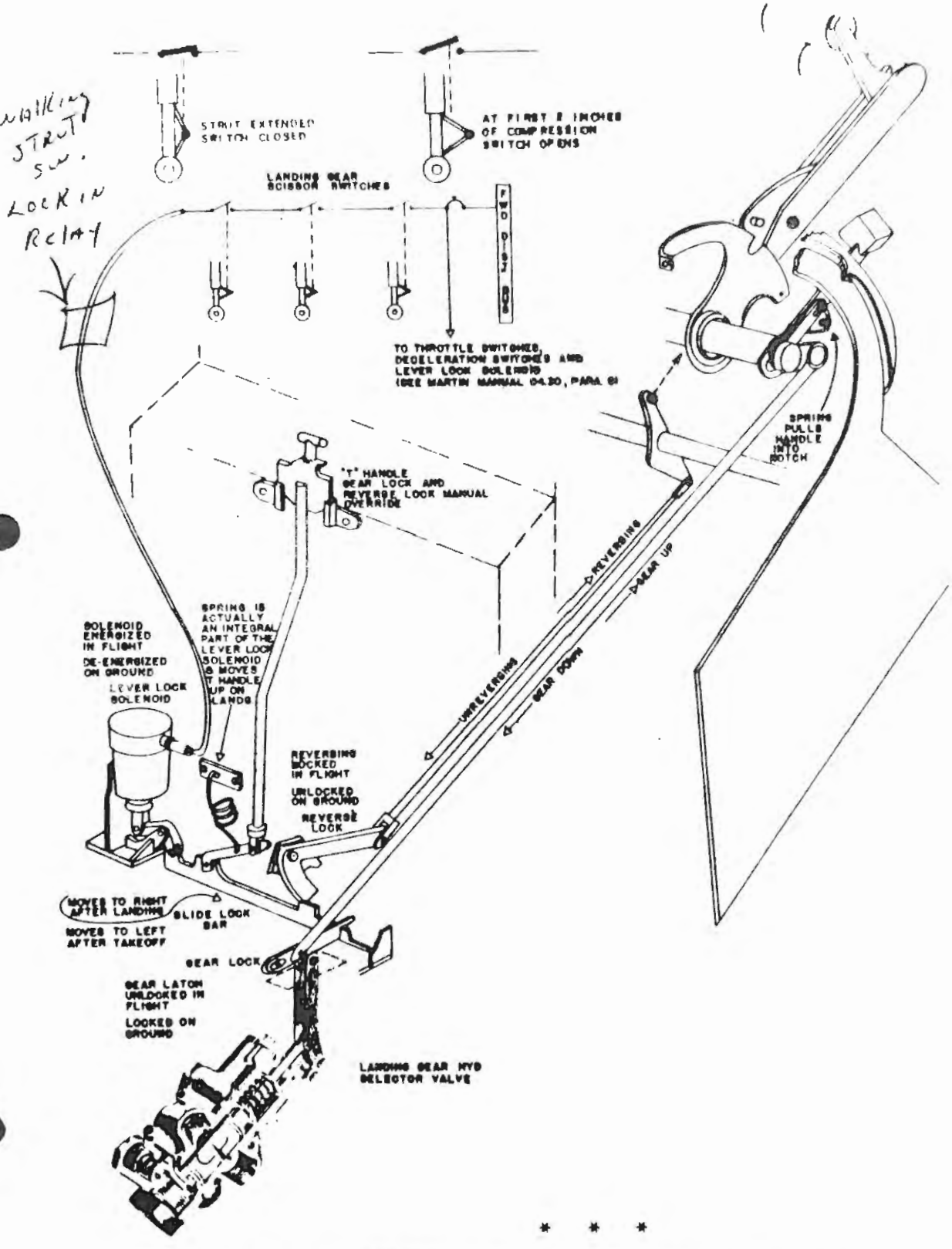


Figure 55. Nose Wheel Steering Controls Rigging Diagram

ILLUSTRATIONS OF PROPELLER OPERATION

H. LANDING GEAR HANDLE/REVERSE THROTTLE LOCK


STRUT EXTENDED SWITCH CLOSED
AT FIRST 8 INCHES OF COMPRESSION SWITCH OPENS
LANDING GEAR SCISSOR SWITCHES
FWD DIST BOX
TO THROTTLE SWITCHES, DECELERATION SWITCHES AND LEVER LOCK SOLENOID (SEE MARTIN MANUAL 04-30, PARA 61
SPRING PULLS HANDLE INTO NOTCH
"T" HANDLE GEAR LOCK AND REVERSE LOCK MANUAL OVERRIDE
REVERSING
GEAR UP
SPRING IS ACTUALLY AN INTEGRAL PART OF THE LEVER LOCK SOLENOID & MOVES T HANDLE UP ON LAND
SOLENOID ENERGIZED IN FLIGHT
DE-ENERGIZED ON GROUND
LEVER LOCK SOLENOID
UNREVERSING
GEAR DOWN
REVERSING LOCKED IN FLIGHT
UNLOCKED ON GROUND
REVERSE LOCK
MOVES TO RIGHT AFTER LANDING
MOVES TO LEFT AFTER TAKEOFF
SLIDE LOCK BAR
GEAR LOCK
GEAR LATCH UNLOCKED IN FLIGHT
LOCKED ON GROUND
LANDING GEAR HYD SELECTOR VALVE

* * *

HYDRAULIC POWER SYSTEM - GENERAL (See Figure 13).

The hydraulic system in this airplane combines the use of an open center type and a closed center type system. The closed center portion of the system maintains an operating pressure of approximately 1500 psi while the open center portion operates at pressure varying from 0 to 3300 psi, depending upon the pressure demand on this part of the system. The two divisions of the hydraulic system receive their supply of fluid and pressure from the same storage and power sources. Hereafter, these systems will be referred to as the open center system and the closed center system which will be understood to be as previously indicated.

An open center hydraulic system is one that supplies pressure upon demand, but which normally permits pump output to flow through the control valve and into the return circuit, at which time lines are kept free of pressure, except that due to line friction. This portion of the hydraulic system is used for operation of the landing gear only.

A closed center hydraulic system is one in which nominal operating pressure is stored in the system, usually with the aid of an accumulator. This is commonly known as an accumulator-pressure regulator type of system. A pressure regulator valve is employed to direct pump output to the closed center system for use as storage until the maximum limit of nominal operating pressure has been obtained, and then the pump is by-passed through the pressure regulator valve into the return system, thereby relieving the pump of all pressure except that due to line friction. Hydraulic pressure from this portion of the system is used for operation of the main gear dual wheel brakes, nose wheel steering and shimmy dampening, actuation of wing flaps, actuation of windshield wipers, application of parking brakes and aileron boost.

The combining of these two types of hydraulic systems into a single system eliminates the need for storing fluid under high pressure (3000 psi) during the entire period of aircraft operation. Instead, it permits the build-up of these high pressures, as they are required, to operate the mechanism that places the greatest load on the hydraulic system.

An emergency hydraulic system is also provided in this airplane. It is a separate system from the normal open center and closed center systems. It is a closed center system, having a nominal operating pressure of approximately 1500 psi, and drawing its fluid supply from the emergency side of the reservoir. This system supplies emergency pressure as the only source of power for actuation of the aft passenger ramp. In the event of failure in the normal system, this circuit provides emergency pressure for brake operation, for the down position of wing flaps and for emergency down operation of the landing gear, all through separate sets of lines. The same emergency power source can be connected to serve as an emergency source of pressure for the operation of systems normally supplied from both the open center and closed center systems. The source of pressure for this system is an electrically operated pump mounted in the fuselage belly. The necessity of installing thermal relief valves, except in the wing flap circuit, is thus eliminated, and cylinder lines are kept free of pressure.

A normal and an emergency reservoir are incorporated in one unit for storing fluid supply. Two constant displacement engine-driven pumps draw their supply from the normal side and are the normal source of pressure for the open center and closed center systems. An electric-driven pump and a hand pump draw their supply from the emergency side and provide pressure for emergency and ground operation.

This chapter is concerned primarily with the power systems. For details of the individual working circuits, refer to Chapter 4 for windshield wipers and ramp operation, Chapter 7 for the wing flap circuit, and Chapter 15 for the landing gears, brakes and nose gear steering.

WARNING

Whenever work of any type is performed on the hydraulic system and hydraulic controlled components, the "EMER. HYD. PUMP" circuit breaker should be turned "off" and placarded before work is started. This circuit breaker, No. 91, is located at the top R.H. side of the main circuit breaker panel on Station 212 bulkhead.

A reduction of pressure in the emergency brake accumulator will cause the hydraulic pressure switch to activate the emergency hydraulic pump if the circuit breaker has not been turned off and render a hazardous working condition.

HYDRAULIC LINES, FLUID, PACKING AND FITTINGS.

Rigid Hydraulic Lines.

Hydraulic lines throughout the system consist of 61ST and 52SO aluminum alloy tubing, varying in outside diameter from 1/4 inch to 1-1/4 inches; stainless steel tubing, 1/4 inch to 5/8 inch in diameter; and flexible hose lines. All supply lines consist of 52SO aluminum alloy tubing. All 3000 psi pressure lines, the up lines for the landing gear circuit, the steering circuit lines at the oleo only, and brake circuit lines at the oleo only, consist of stainless steel tubing. Flexible hose lines are also used in the landing gear and steer circuits where there is relative motion during landing gear and steering wheel operation. All other pressure and operating lines consist of 61ST aluminum alloy tubing. Hydraulic lines are protected from excessive vibration by the use of fairleads and clamps which attach the tubing to the structure of the airplane.

Flexible Hydraulic Lines.

Flexible lines in this system consist of hose assemblies with detachable, swivel type end fittings. This type of line is used to accommodate relative motion of the mechanism to which it is attached, and to facilitate the removal of units. Flexible lines in the normal supply, power, and return circuit for both systems are used between the engine-driven pumps and the firewall. Only high pressure hose is used

Hydraulic Lines Code.

All hydraulic lines in this plane have the new type color code combined with a visual identification symbol for persons who are color blind. Refer to chart in Chapter 22 for details.

Hydraulic Fluid.

Hydraulic fluid, Specification No. MIL-O-5606 is the only type of fluid used in this system. It is a mineral base fluid, and it maintains a low viscosity within an operating temperature range of -65°F to + 160°F. Refer to Chapter 14 for further identification of this fluid.

Packings And Seals.

Doughnut type (O-ring) packings, made of synthetic rubber, are installed in units to seal them against internal and external leakage. A leather back-up ring is sometimes used to protect the O-ring packing against damage or wear by keeping it from being forced against the sharp groove in which it is installed when pressure is applied and also to prevent extrusion of the doughnut seal under high or excessive pressure. Actuating cylinders that are subjected to high or excessive pressure are equipped with leather back-up rings on one or both sides of the O-ring packings in the cylinder.

Fittings.

Sections of tubing, both aluminum alloy and steel, are joined to each other, and to other fittings in the system, through the use of aluminum alloy Ermeto (ER) flareless tube fittings for all diameters up to and including 5/8 inch. On all lines larger than 5/8 inch in outside diameter (1 inch and 1-1/5 inch) AN type fittings are used. An Ermeto fitting requires no flare on the end of the tube, thus eliminating the process of tube flaring. It also assures a pressure-tight joint in lines throughout a major part of the system. The fitting works on the principle of a hardened ring or sleeve that indents itself into the outside surface of a plain tube when the tube is slipped into a coupling and tightened by a nut. Refer to Installation of Ermeto Couplings, this chapter.

Exhausting Pressure In Power Circuits And Return System.

The lines in the open center power circuits are free of pressure after both engines are turned off. At this time the landing gear valve is in neutral position, and the open center pressure line to the pressure regulator is vented to return through the landing gear control valve. With both engines running, the landing gear control valve in neutral position, and the closed center system charged with 1500 psi pressure, the open center pressure line will show pressure due to friction (approximately 300 psi). In the event that the landing gear control valve fails to function properly or the pressure regulator valve fails to cut out at the required pressure, it is possible to open the pump pressure line to return, by actuating the flight depressurization valve on the floor to the left of the pilot's seat. This is provided primarily in case of an emergency of this nature while the airplane is in flight. During ground test procedures and before disconnecting lines, pressure in the closed center system is exhausted by opening the "BLEEDER VALVE" on the hydraulic panel. Pressure in the emergency brake accumulator can be exhausted only by operation of the emergency brake.

Air In Hydraulic System.

When air gets into the fluid lines of the hydraulic system it prevents smooth operation of actuating mechanism. Such a condition occurs when line disconnections are made for removal and installation of units or tubing, or when the required fluid level is not maintained in the reservoir. When such a condition exists, air must be bled from the system by special procedures. If there is evidence of air in lines between the control valve and the actuating cylinder or cylinders, or if a line has been disconnected, air must be bled through the bleeder ports in the cylinders. Refer to Bleeding Air from Normal Power System.

Filtration of Hydraulic Fluid.

Under normal conditions, fluid in this system is kept free of dirt or other foreign matter by a replaceable filtering element installed in the system reservoir. All fluid returning to the reservoir from operating circuits passes through this filter. In the event that a clogged condition of the filter should exist, returning fluid by-passes the filter and enters the reservoir proper unfiltered.

WARNING

When servicing reservoir, add only clean, un-contaminated fluid as the screen in the filler opening cannot remove minute particles of dirt.

Normal Supply, Power and Return Circuit. (See figure 15).

The open and closed center hydraulic systems function through the same supply, power and return circuits. The units in this basic circuit consists of the reservoir, a vent line filter, an integral fluid filter and a filler screen; two engine driven pumps; two firewall shut-off valves; suction and pressure test outlets; an open center pressure relief valve; a flight depressurization valve; a bleeder valve; a pressure regulator valve; the open center pressure transmitter and snubber and the closed center pressure transmitter; a closed center system pressure relief valve; a main accumulator; a parking brake accumulator and five check valves.

A common return line carries fluid back to the reservoir from the adjoining return lines of these units, and those in the sub-systems. Another return line is routed to the reservoir from the drain port of the pressure regulator, and from the return side of the brake control valves.

Fluid supply for the system is stored in a reservoir assembly, and is fed by differential air pressure and gravity head to the hydraulic pumps. This unit is vented to the pressurized portion of the airplane. A filter in the reservoir vent line removes impurities from the air as it enters the reservoir, and a filter in the tank removes impurities from the fluid.

The suction line to each engine-driven pump passes through a shut-off valve mounted on the firewall. This valve is closed only to stop the flow of hydraulic fluid from the reservoir in case of fire in the nacelle or to facilitate removal of the engine, or of the hydraulic pump.

A test outlet is installed in the common suction line and one in the common pressure line of the hydraulic pumps as a provision for ground testing the hydraulic system with an auxiliary source of power.

A check valve is installed in the pressure line from each engine-driven pump. Should either pump become defective, the check valve prevents loss of pressure from the good pump into the defective pump. A check valve in the line to the pressure test outlet prevents loss of pressure in case of leakage because of a weakened test outlet coupling or adjoining line.

The engine-driven pumps are protected against excessive pressure and overload by the open center system pressure relief valve. Likewise, the basic units and pressure lines in the closed center system are protected against excessive pressure by its pressure relief valve

The pressure regulator separates the open center system from the closed center system by unloading the engine-driven pumps when the closed center system has been charged to a predetermined maximum operating pressure. The open center system is that portion of the power circuit from the pressure lines of the engine-driven pumps to, or through, the landing gear control valve to the pressure regulator. It also includes the return line from the pressure regulator to the reservoir.

If pressure in the closed center system is below cut-in pressure of the pressure regulator, and if the landing gear control handle is in neutral, fluid will be discharged by the pumps through the landing gear control valve, through the pressure regulator, and into the closed center system until the regulator valve cuts out. The landing gear is the only component that operates on the open center system. The landing gear takes precedence over any other hydraulically actuated mechanism in the airplane, since pressure from the pumps must first pass through the landing gear control valve. This means that if the landing gear is actuated before the closed center system is charged to the cut-out pressure of the regulator valve, pressure would be limited for wing flap operation or windshield wiper operation until such time as the landing gear valve is returned to neutral position. Maximum pressure in the open center system is limited to 3300 psi by the main pressure relief valve.

If pressure in the closed center system is at the cut-out pressure of the regulator valve, flow into this system from the pumps is cut off by the regulator valve and fluid is then circulated through the return line of the regulator valve and back to the reservoir.

The closed center system is that portion of the basic power circuit where nominal operating pressure is stored in the system by an accumulator. Two accumulators are installed in the pressure line of the closed center system. One accumulator stores pressure for operating circuits in the closed center system. The other accumulator stores pressure for parking brakes, and is separated from the main pressure line of this system by a check valve. In this way, pressure is provided for parking brakes even though it may be exhausted throughout the rest of the closed center system.

Hydraulic Reservoir and Associated Components (See figure 19).

The reservoir assembly consists of the following components: sight gage, vent and vent filter, fluid filter, and a protecting cover assembly.

Reservoir (See figure 19).

The reservoir is an eliptical-shaped tank approximately 36 inches in length and is located on the aft side of station 212 bulkhead, at the forward entrance door. Refer to series 3 for capacity. The reservoir serves a basic purpose in that it stores a supply of fluid to offset volume change during operation of various units in the system. It also allows for volume change due to temperature variation, and it provides an emergency supply in case of failure in the normal system. The oil is filtered and entrained air escapes in the reservoir.

Reservoir (Cont.).

The bottom end of the tank is welded closed except for holes cut into it for two suction ports and a drain port. There is a removeable cap installed on the top end of the tank for the purpose of servicing the reservoir filter within. A partition divides the inside area of the tank into two compartments, one for the normal supply of fluid, and one for the emergency supply. A tube from the filler assembly connects directly to this partition and when the tank is refilled hydraulic fluid is directed into the emergency compartment of the reservoir. Two holes drilled in the partition permits flow into the normal compartment, and keeps the emergency fluid at a lower level. A strainer, constructed of a corrosion resistant steel wire cloth screen, is installed inside the filler assembly to strain sediment out of the fluid at the time the supply is replenished. During this procedure, fluid flows first into the emergency supply compartment, and then overflows into the normal supply compartment. A cap and adapter assembly is screwed into the filler assembly as a protective cover and seal.

An internal tube extends from the filter compartment in the top of the reservoir down through the metal plate that covers the normal supply compartment. Fluid that is returned from the system is strained through the filtering element and then flows through this tube into the normal supply compartment.

A baffle plate is installed on each side of the tank, where the two return ports are located on the top shell. This plate checks a swirling movement of the fluid as it flows into the tank from the return system and thus prevents air from being drawn through the fluid into the pumps.

Two suction ports and one drain port are on the bottom surface of the tank. One suction port is for the normal supply compartment, and the other suction port and drain port is for the emergency supply compartment. The normal drain port is located on the outboard side of the tank approximately 7½ inches from the bottom of the reservoir. During servicing procedures, the drain ports are used for removing fluid and sediment that has settled in the tank.

A sight gage is attached to the outboard aft side of the reservoir and provides visual indication of fluid level in the tank. A vent port and filter is located on the outboard side of the reservoir just below the filter compartment.

Servicing Reservoir (See figure 19).

Four fluid level indicator placards are mounted on the reservoir cover with arrows pointing to the sight gage which indicates the following fluid levels, from top to bottom "FULL ZERO PRESS.", "REFILL ZERO PRESS", "FULL SYSTEM CHARGED", and "REFILL SYSTEM CHARGED". A placard on the inside of the filler door gives filling instructions.

Reservoir Sight Gage (See figure 19).

A sight gage is attached to fittings in ports on the aft side of the reservoir. It provides a visual indication of fluid level in the tank. Placards are mounted on the tank cover and adjacent to this gage, to indicate refill and full levels with system charged and with zero pressure. The gage is constructed of Polyester Gage glass tubing.

Reservoir Vent And Vent Filter (See figure 1).

A vent port is located on the side of the reservoir just below the filter compartment. An external vent line extends from this port down one side of the reservoir to the vent filter and then ending near the bottom surface of the reservoir. This filter vents the inside of the reservoir to cabin pressure, so that the air in fluid returning to the reservoir has free escape, and so that there is pressure on the fluid all the time. The filter removes dust particles from air drawn into the reservoir. The filter has a capacity of three cubic feet per minute of clean sea level air. The element has a filtering area of 36 square inches, and in reverse flow the element will act as a relief valve and will open at 4 to 5 psi differential pressure.

Reservoir Fluid Filter.

A micronic filter is installed in the top shell of the reservoir and is enclosed by a cover assembly held in place by wing nuts. The filter element can be removed for servicing by the removal of this cover. Fluid entering the reservoir through the return port strain through the filter element and then flows through a tube into the normal supply compartment.

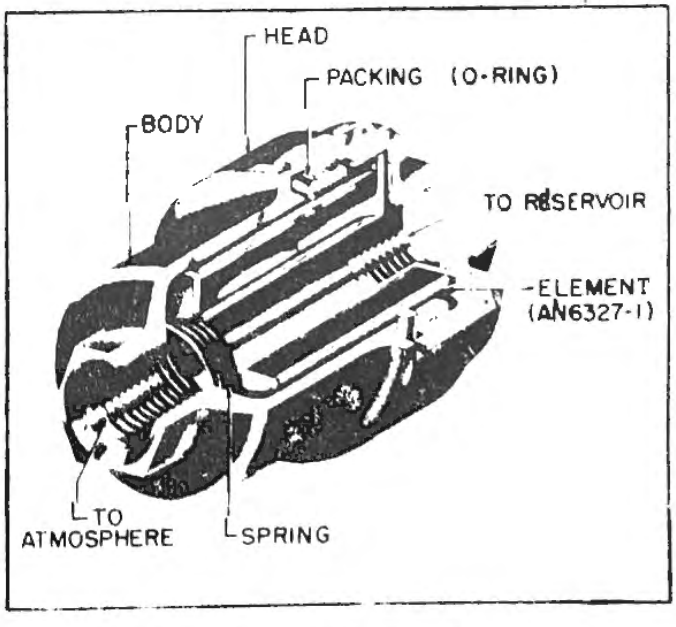


Figure 1. Reservoir Vent Filter

Reservoir Fluid Filter (Cont.).

A checked flow through the filtering element, due to a clogged condition of the element, will result in back pressure. When the differential pressure becomes too great, the relief valve, installed in the top shell, opens and fluid outside the filter by-passes the filter and flows directly into the normal supply compartment. The design of this relief valve is a poppet type check valve, except that a special spring is used, and it must be installed with the arrow on the body pointing toward the bottom of the tank which would be the direction of flow when the valve is open.

To assure an unrestricted flow of hydraulic fluid through the micronic filter it should be removed and checked for cleanliness at approximately 100 hours. If the element is dirty it should be replaced and a new one installed.

Cover for Hydraulic Reservoir (See figure 19).

A cover assembly of aluminum alloy is fastened by spring fasteners to webs and angles on the bulkhead at station 212 and on the circuit breaker box. It enclosed the aft side of the reservoir. A cut out is provided on the outboard side of the cover for viewing the reservoir sight gage. A bottomed hinged access door with a push type release is provided for access to the reservoir filler assembly. The top and bottom sections of this cover are hinged so as to provide access to equipment above and below the reservoir, and behind the cover. Nameplates for fluid levels in the reservoir are mounted on the cover along one side of the cut out for the sight gage, and a placard for fill instructions is located on the inside of the filler assembly access door. This cover serves as a protection to the reservoir against damage during cargo loading.

Spare Hydraulic Oil Can Stowage (See figure 19).

A rectangular metal cup is riveted to the top of the reservoir cover for stowage of a one-gallon can containing hydraulic fluid. A strap extends around the vertical axis of the can and is held by a clamp on the cup. This stowage provision assures an extra supply of hydraulic fluid within easy reach.

ENGINE-DRIVEN HYDRAULIC PUMPS (See figure 15).

The engine driven pumps, one mounted on the accessory section of each engine, supply pressure for operation of all the hydraulic units in the closed and open center systems. These pumps are a constant displacement gear type pump, each having an output of 5.5 gallons per minute at cruising speed and 7.8 gallons per minute at take-off engine speed. The pump is geared to the engine at a 1 to 1.4 ratio and is installed for clockwise rotation.

Fluid is applied to the pumps through a suction line from the main compartment of the reservoir. The pressure line from each pump converges into one common pressure line to supply the systems.

The pumping action is obtained by a pair of concisely meshed precision steel gears rotating within a closely fitted aluminum housing. As the gear teeth separate on one side, the tooth space is filled with fluid from the inlet port (reservoir suction line), and is carried around to the opposite side where meshing teeth displace fluid into the outlet port (pump pressure line). The pump is pressure loaded, in that the pressure it develops is utilized to maintain contact between the silver plated bearings at the end of the gears.

The housing of the pump consists of the body and cover. The body contains the drive shaft, seal parts, two bronze body bearings, and two gears. One of these gears is rotated directly by the engine. This drive gear meshes with and drives another gear. The steel gears are supported on bronze bearings within the closely fitted housing. The gear shafts are hollow.

The pump mounting flange contains four holes for installation on the engine accessory pad. The cover is mounted on the body and is secured by studs and nuts. It houses the inlet and rotational check valves, and two end ports used as inlet and outlet ports. The drive shaft extends beyond the mounting flange of the pump and splines directly into the drive gear with a loose fit. This accommodates slight misalignment between the engine driving member and the axis of the drive gear.

The drive shaft has an undercut (safety shear) section to protect the airplane engine and the pumping parts in the event of pump failure due to excessive loading, or other causes. There is a positive seal maintained between the retainer and the drive shaft. This seal is designed to accommodate slight misalignment with respect to the pump drive shaft and the engine drive, and is also unaffected by forward thrust on the drive shaft. The fluid in the seal chamber, maintained under pressure by the check valve, lubricates the moving parts and prevents air from entering the pump through the seal.

A drain line is attached to the port at the bottom center point of the pump mounting flange, and it is routed to the drain manifold that opens through the skin on the under surface of the engine nacelle. This line carries away the slight amount of fluid that may work past either the pump or engine drive seal.

To permit reversal of rotation, a check valve, one long plug, and one short plug, are installed in the cover of the pump, The valve seat and long and short plugs incorporate a seal ring which is positioned so as to allow fluid to pass into the proper communication channel and prevent the fluid from entering the other channel where it is not desired. An instruction plate is attached to all pumps with this type of valve arrangement and it shows the proper location of the plugs for a specific direction of rotation.

ENGINE-DRIVEN HYDRAULIC PUMP (Cont.).

Flexible high pressure, fire resistant hose lines are connected to the inlet and outlet ports of the pump and extend to fittings on the firewall.

Two pumps are used to provide reliability. However, if one pump becomes inactive, the other pump supplies adequate fluid for operation of the system and only results in a slight increase in gear retraction time.

FIREWALL SHUT-OFF VALVE.

A shut-off valve assembly is mounted on the aft lower left side of the firewall in each nacelle. The assembly is a combination of oil, hydraulic, and fuel shut-off valves. The three valves are simultaneously opened or closed by a control handle under the pilots' glare shield, one for the left engine and one for the right engine. The handles are labelled "SELECTOR ZONE 2, FIREWALL SHUT-OFF". Each control handle is linked to a yoke at one end of the shut-off valve unit. This linkage actuates a rotor within the valve that opens or closes the ports connected to the oil, hydraulic, and fuel lines.

The suction line from the hydraulic reservoir branches off into two lines, one line to each engine-driven pump. Refer to Chapter 19 for a view of the valve, description and rigging.

GROUND TEST OUTLETS. (See figure 15).

A test outlet is installed in the suction line, and a test outlet is installed in the common pressure line. The purpose of the suction and pressure test outlets is to provide connections for an auxiliary source of supply and power when ground testing the system with an auxiliary test unit. These two outlets are mounted together in an externally accessible box compartment recessed into the lower left side of the fuselage forward of station 320. At this point a line tees off the main suction line and off the main pressure line to the test outlets in this compartment. The box cover over these units opens on hinges to provide accessibility.

This type of test outlet is identical to the coupling half of a disconnect fitting that acts as a check valve. The unit is provided with a dust cap that protects the internal poppet, and fluid in the line, against dirt. A chain on the cap is attached to structure so that the cap cannot be lost or misplaced when removed from the outlet.

Each outlet is sealed by the spring-loaded poppet in the coupling half. An auxiliary test unit is connected to the test outlets by removing the dust caps, and joining the coupling halves on the lines of the test unit to those on the outlets. Tightening the union nuts of these coupling units opens these lines to free flow in both directions.

PRESSURE REGULATOR VALVE (See figure 23).

The pressure regulator valve is installed in the main pressure line downstream of the landing gear control valve and is located on the forward end of the hydraulic panel, left side of nose wheel well. This unit acts as an automatic unloader valve for the engine-driven pumps, and as a regulator for pressure in the closed center system. The internal parts of the pressure regulator are housed within a square-shaped body comparatively small in size (2.66 x 2.38 x 1.25 inches).

There are four ports in this valve. The ports opposite each other are connected to the open center system and to the closed center system. There is a poppet-type check valve between these ports. When the closed center system is being charged with pressure, flow from the engine-driven pumps is directed through the landing gear control valve (in neutral position) and through the inlet port of the regulator valve. The check valve in this passage then opens to permit flow into the pressure line of the closed center system. The fluid port adjacent to the adjustment screw, on the opposite side of the valve, is connected to the return system so that flow from the pumps is by-passed into the return line as soon as the closed center system is charged with the required pressure. A drain port is adjacent to the closed center system port and is connected to the return line. Fluid drains through this port from the sensing unit assembly at the time flow from the pumps is by-passed into the return circuit.

The regulator valve incorporates a sensing unit assembly that regulates the pressure in the closed center system. Because of the delicate construction and design of this feature, a filtering element is installed in the assembly to offset the possibility of an unseated sensing ball or sensing poppet because of minute sediment in the fluid. The setting of this sensing unit is made by an external adjustment screw which governs the load on the spring within the sensing unit.

A restrictor screw is installed in the body of the valve between the sensing unit assembly and the return port. A plastic insert, as a locking device, keeps the setting of the restrictor screw secure, once it has been made. The purpose of this restrictor screw is to limit flow between the sensing unit assembly and the area behind the piston in the return port, so that thumping of the valve, or chattering, is greatly reduced. This makes a comparatively quiet valve in operation.

This unit should normally require no service between overhauls. If malfunctioning should occur, replace it with a serviceable unit. Do not attempt to adjust it.

Operation Of Pressure Regulator Valve.

In figure 23, this valve is shown in no flow position. In this position, there is no flow from the pumps, and the closed center system is not charged. The piston in the return port is seated by spring load and the check valve in the passage between the two systems is also seated by spring load. The spring under the adjustment screw is under the load required to keep the sensing ball seated. This same force also causes the sensing poppet to be slightly unseated.

In figure 15, the view shown of this valve in "cut-in" position indicates how the unit operates when pressure in the closed center system has dropped off to a predetermined minimum. At this point, pressure in the closed center system is not sufficient to overcome the spring load against the sensing ball, so this ball is seated, which action unseats the sensing poppet and permits flow around the unseated sensing poppet, through small passage in the poppet seat, and through the restrictor passage into the area back of the piston in the return port. The pressure assists the spring pressure to keep the piston seated and close the return port to flow from the pumps. Flow from the pumps then unseats the check valve in the passage between the two systems allowing flow into the closed center system.

In figure 15, the view shown of this valve in "cut-out" position indicates what change takes place in the regulator when pressure in the closed center system has reached the predetermined maximum pressure. (See Series-3 in this Chapter for cut-out and cut-in settings) The "cut-out" pressure in the closed center system is then strong enough to overcome spring load against the sensing ball This force unseats the sensing ball, which in turn allows the sensing poppet to be seated. At this point, fluid trapped in the area behind the piston in the return port flows back through the restrictor passage, through the drilled passages in the poppet seat, past the lands around the spool, and out the drain port. This release of trapped pressure in the area behind the piston in the return port makes it possible for flow from the pumps to follow the path of least resistance by compressing the spring and unseating the piston. In the meantime, spring tension and pressure in the closed-center system has seated the check valve in the passage between the two systems.

The engine-driven pumps are unloaded when this valve is in "cut-out" position. In the event that this valve fails to by-pass fluid into the return system when the closed center system is charged, the open center system pressure relief valve will open to relieve excessive load on the pumps.

FLIGHT DEPRESSURIZATION (EMERGENCY BY-PASS) VALVE. (See Figure 2)

The flight depressurization valve, commonly known as emergency by-pass valve, is installed between the main pressure and return lines of the open center power circuit. This valve is installed under the cockpit floor with the manually operated control handle fastened directly to the valve and extending through the cockpit floor to the left and forward of the pilot's seat. It is accessible by removing the left side pressure panel in the nose wheel well. The body of the valve is comparatively small and houses a poppet that is held on its seat by a spring retained [illegible] cap that is attached to the body [illegible]. O-ring packings are installed [illegible] it against external leakage. [illegible] and return ports are on opposite sides of the body, with the return port slightly above the pressure port. A knobbed lever is attached to one end of the valve, and it extends through the floor of the pilots' compartment, on the left side, and ahead of the pilot's seat.

The nameplate for this unit bears the label "HYDRAULIC BY-PASS VALVE". When the lever is in extreme forward position, the valve is "CLOSED". The poppet is held in its seat by spring load, so that the pressure and return ports are closed to each other. When the lever is moved aft to a vertical position, the valve is "OPEN". The poppet is unseated by a cam on the lever so that there is flow between the pressure and return ports.

A guard assembly of aluminum alloy is installed on the floor in an upright position, and at the inboard side of the valve lever. The top of the guard curves over the lever to protect it against anything that might inadvertently move it. A spring is installed in [illegible]ged section of the guard to hold it sec[illegible]n the

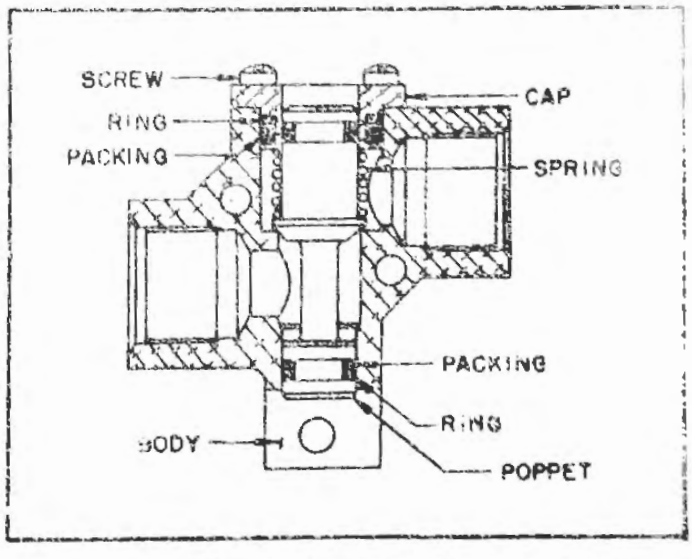


Figure 2. Flight Depressurization Valve

FLIGHT DEPRESSURIZATION (EMERGENCY BY-PASS) VALVE (CONT.).

upright position, and also in the horizontal position when it is moved to this position for access to the valve lever.

Function Of Depressurization Valve.

The flight depressurization valve is manually actuated by the pilot at his own discretion. He will only use it to by-pass fluid from the pumps directly back to the reservoir in case the pressure regulator valve fails to "cut-out". If pump pressure could not be by-passed in an emergency such as this, the pumps would have to operate under pressure equivalent to the relief setting of the closed center system pressure relief valve. This would cause excessive overheating of fluid which would cause extensive damage to units in the hydraulic system, and could possibly become a fire hazard.

OPEN CENTER SYSTEM PRESSURE RELIEF VALVE (See figure 21)

This relief valve is installed in the main pressure line upstream of the pressure regulator and landing gear control valves. It is a pilot operated type pressure relief valve

As shown in figure 21, the body of this valve has a right angle pressure port at the bottom, and a right angle return port slightly above the pressure port, and on the opposite side of the valve An adjustment screw extends through the cap on top of the valve.

CAUTION

This valve can be physically interchanged with the wing flap load relief valve and the gear down line relief valve, each of which has a different adjustment setting; therefore it must be determined a valve is the correct one before installing it. To do this, compare the cracking pressure shown on the valve placard with that specified in series-3 of this chapter.

This pilot-operated relief valve includes a pilot valve, spring, housing, guide, bushing, and seat, and a main valve, spring, housing, guide and seat. O-ring packings are installed to seal the valve against internal and external leakage. The adjusting screw determines the spring load on the pilot valve, and it is set to the cracking pressure of the valve as specified in series-3 of this chapter. A setscrew in the valve cap keeps the adjusting screw in the desired position.

This valve should normally require no servicing between overhauls. If malfunctioning should occur, replace with a serviceable unit. Do not attempt to adjust this valve.

Principle Of Operation Of Open Center Relief Valve.

This pressure relief valve prevents an excessive buildup of pressure in the open center power circuit. In the event of failure of the landing gear control valve to return to neutral after the gear cylinders bottom, this unit limits the maximum pressure output of the engine driven pumps.

As shown in figure 21, the relief valve goes into operation when the pilot valve is actuated. As pressure through the pressure port of the valve builds up against the poppet, it overcomes the spring load on the poppet that is determined by the adjusting screw in the cap. As the poppet unseats, fluid flows through the drilled passages in the main valve, and builds up sufficient pressure in this area to raise the main valve off its seat. As soon as the main valve is unseated, there is flow through it to the return port of the valve.

As pressure drops to the predetermined pressure setting of the relief valve, the spring load on the poppet overcomes hydraulic pressure against this valve and its seats. Spring load then cause the pressure which is holding the main poppet valve open to bleed off. This allows it to seat and stop hydraulic flow between the pressure and return ports. A drilled hole in the main valve housing permits passage for any leakage between the main valve and the main valve housing. "O" ring seals are used as packing to prevent internal and external leakage of hydraulic fluid.

BLEEDER VALVE (See figure 15).

A needle type bleeder valve is installed between the main pressure and return lines of the normal closed center system and is located near the aft end of the hydraulic panel in the nose wheel well. The aluminum alloy body of the valve houses a stainless steel stem with a cone-shaped end that seats against the pressure port of the unit when the diamond knurled knob on the external end of the stem is turned in the extreme clockwise position. The right angle return port is opened to the pressure port when the stem is moved away from its seat by the counterclockwise turning of the knurled knob on the external end of the stem.

The purpose of this bleeder valve is to exhaust pressure in the closed center system. It is so connected in the system that pressure in the parking brake accumulator can also be exhausted through this valve. This unit is used primarily during ground servicing procedures and should be lockwired closed after completion of servicing and before flight.

Failure of the closed center system to maintain pressure is sometimes caused by not having this valve securely closed, or by leakage due to a worn or damaged valve seat.

CLOSED CENTER SYSTEM PRESSURE RELIEF VALVE (See Figure 3).

The closed center system pressure relief valve is installed between the main pressure and return lines of the normal closed center power circuit and is located on the hydraulic panel in the nose wheel well.

The body of the valve houses a piston, piston seat, guide and spring. The piston is held on its seat by the spring, the tension of which is varied by the turning of an adjustment screw in the head of the valve. The spring load determines the relief setting of the valve. This setting is made on a test bench and in accordance with the specified relief pressure for the closed center system.

There are four fluid ports in this valve arranged as opposite ports, with one pair above the other. In this system one relief valve is installed so that the pressure line connects to one bottom port, with the opposite port plugged, and the return line connects to one top port, with the opposite port plugged. Ports are identified on the valve.

This valve should normally require no servicing between overhauls. If malfunctioning should occur, replace with a serviceable unit. Do not attempt to adjust this valve.

Closed Center System Relief Valve - Principle Of Operation

Spring load on the piston is sufficient to keep it seated until pressure in the system becomes excessive. When it reaches the cracking pressure of the relief valve, it overcomes the spring load, and the piston is partially unseated. The valve is open to full relief when there is maximum flow through the valve. As soon as the piston is unseated, the pressure port is vented to the return port, and pump delivery is sent into the return system until such time as there is a pressure drop to the point where spring load against the piston is greater than hydraulic pressure.

This relief valve provides protection for the closed center power circuit against excessive pressure which might occur from a pressure regulator valve that is not functioning properly.

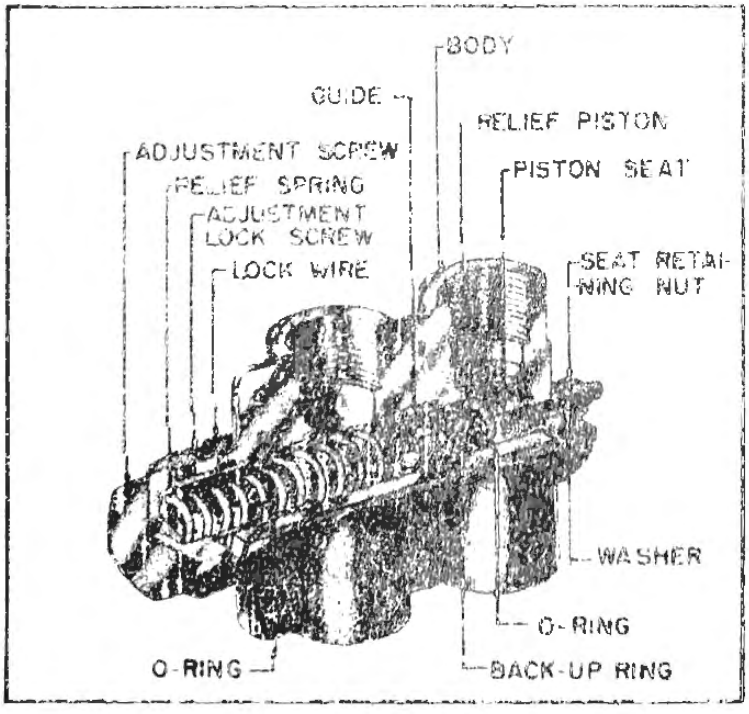


Figure 3. Closed Center System Pressure Relief Valve

MAIN ACCUMULATOR ASSEMBLY (See figure 4).

An accumulator, 7½ inches in diameter, is installed in the closed center power circuit and is mounted above the hydraulic panel, left hand side of the nose wheel well. Its purpose is to provide for an instantaneous supply of additional fluid under pressure for short operations requiring volume in excess of pump capacity, and to prevent too frequent operation of the pressure regulator valve. Refer to Maintenance Notes for servicing accumulator.

This type of accumulator is a steel shell spherical in shape and contains a synthetic rubber bladder which separates the air and oil chambers. The bladder has a washer fastened to the upper portion of it to prevent extrusion of the bladder through the fluid port. A cap assembly seals the open end of the bladder when installed and contains an air valve which provides a means of inflating and deflating the accumulator. The retainer is a ring nut which threads into the shell and holds the cap firmly against the flange of the bladder.

The bladder is so molded that the upper portion of the sphere has a heavier wall than the lower portion and therefore will permit the upper section to fold into the lower section. The outside of the bladder also has a number of raised buttons molded onto it to permit the fluid entering the accumulator to flow around the bladder's outside wall. This exposes enough surface area to permit the fluid entering under pressure to compress the air inside the bladder and prevents trapping oil when discharging. The accumulator is charged with nitrogen (preferred) or dry compressed air, to a preload pressure specified on the respective nameplate beside the installed accumulator.

The accumulator is equipped with an air filler valve and pressure gage assembly in the air chamber end of the unit. Refer to Air Valves And Cores for the description of the filler valves and to Hydraulic Pressure Indicating System And Air Gages for details and principle of operation of the gages.

Accumulator Principle Of Operation.

When hydraulic pressure in the system is at zero, and the accumulator is charged with the required pre-load pressure, the bladder is fully extended to the top of the fluid chamber. As the oil is charged through the fluid port, the upper hemisphere of the bladder is forced toward the bottom, further compressing the air in the bladder. When fully charged with fluid, the bladder is in the shape of a "U" in the bottom of the accumulator. When actuation of a hydraulic unit in the system places a demand upon the accumulator the compressed air forces the fluid out of the accumulator as required or until all the oil is exhausted. In this manner, the accumulator supplies an instantaneous supply of high pressure fluid.

The greater the initial air charge, the smaller fluid volume stored, and the fewer times a unit can be operated. The smaller the initial air charge, the greater the oil volume, but less pressure with which to force it into the system. For these reasons, it is important that the correct initial air charge is maintained at all times. Refer to Air Valves And Cores for description and view of the air valve assembly.

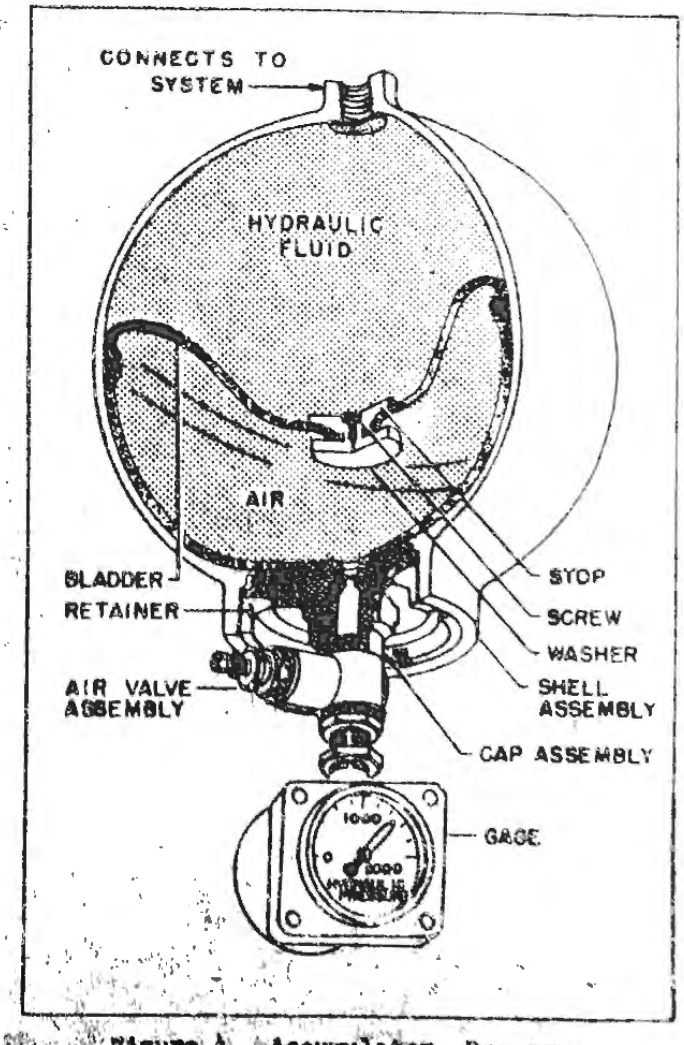


Figure 4. Accumulator, Pressure Gage And Air Filler Valve

EMERGENCY PRESSURE SWITCH (See figure 7).

The emergency pressure switch is installed in the emergency brake pressure line between the check valve and the emergency brake accumulator. It is located on the aft end of the hydraulic panel in the nose wheel well. The location of the pressure switch in the emergency brake pressure line limits its control over the electrically-driven emergency pump to only the emergency brake hydraulic circuit. A pressure drop in the brake circuit to a predetermined minimum will actuate the switch, which in turn will close an electric circuit to the electric pump. The pump will supply pressure to the brake circuit until it reached a predetermined maximum. This maximum pressure will then actuate the switch to cut-out position so that the electric circuit to the pump is opened, and the pump stops running. This unit is an automatic device that controls the storage of pressure in the emergency brake circuit at all times.

The pressure switch is a combination electrical and hydraulic unit. Internal parts of the unit are housed within a square-shaped metal cover that screws onto the body of the switch. A fluid port and an electric plug receptacle are in the body of the switch. The emergency brake pressure line connects to the fluid port, and the switch is connected to the electrical system and electric-driven pump by way of the plug receptacle. (See figure 17).

As shown in figure (7), the design of this switch incorporates a Bourdon tube, spring lever arm, micro switch assembly, adjustment spring and a adjustment screw.

The Bourdon tube is connected at the open end to the hydraulic fluid port. A micro switch actuating plate is attached to the closed end of the tube. An adjustment screw and spring are provided at the base of the micro switch assembly for adjustment of the micro switch to maximum and minimum pressure settings.

This unit should normally require no service between overhaul periods. Malfunctioning is cause for replacement with a serviceable unit.

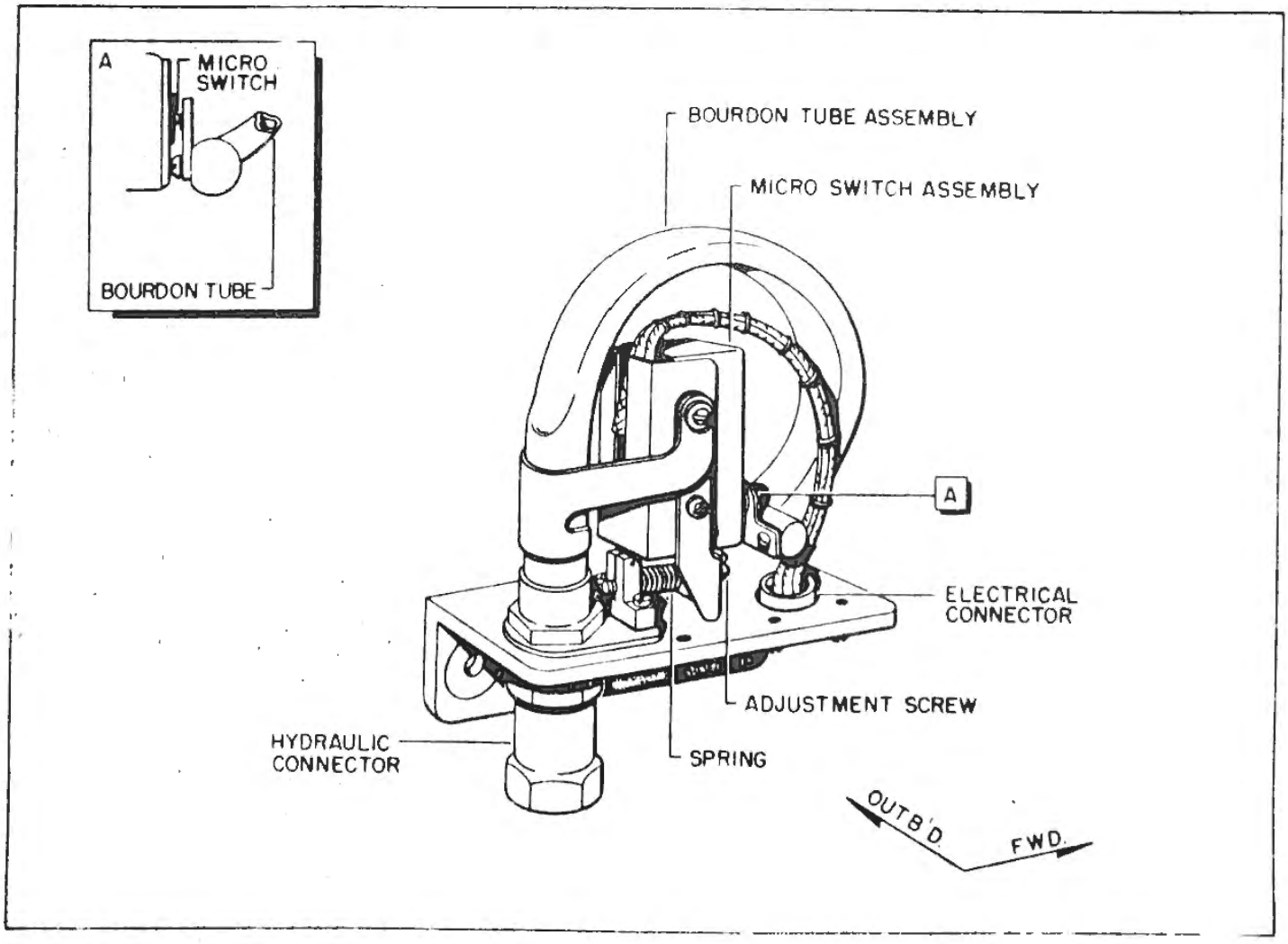


Figure 7. Emergency Pressure Switch (With Cover Removed).

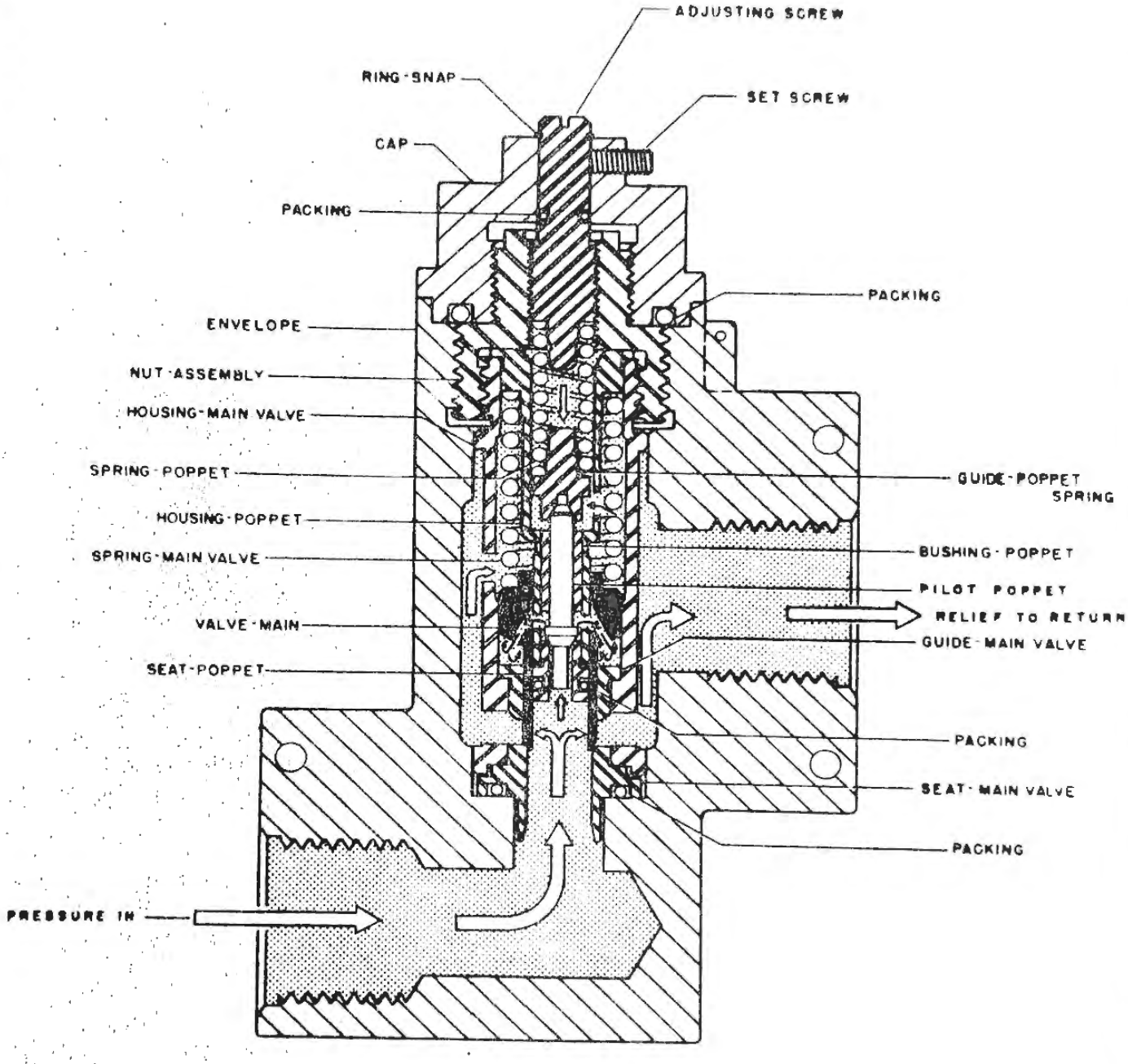
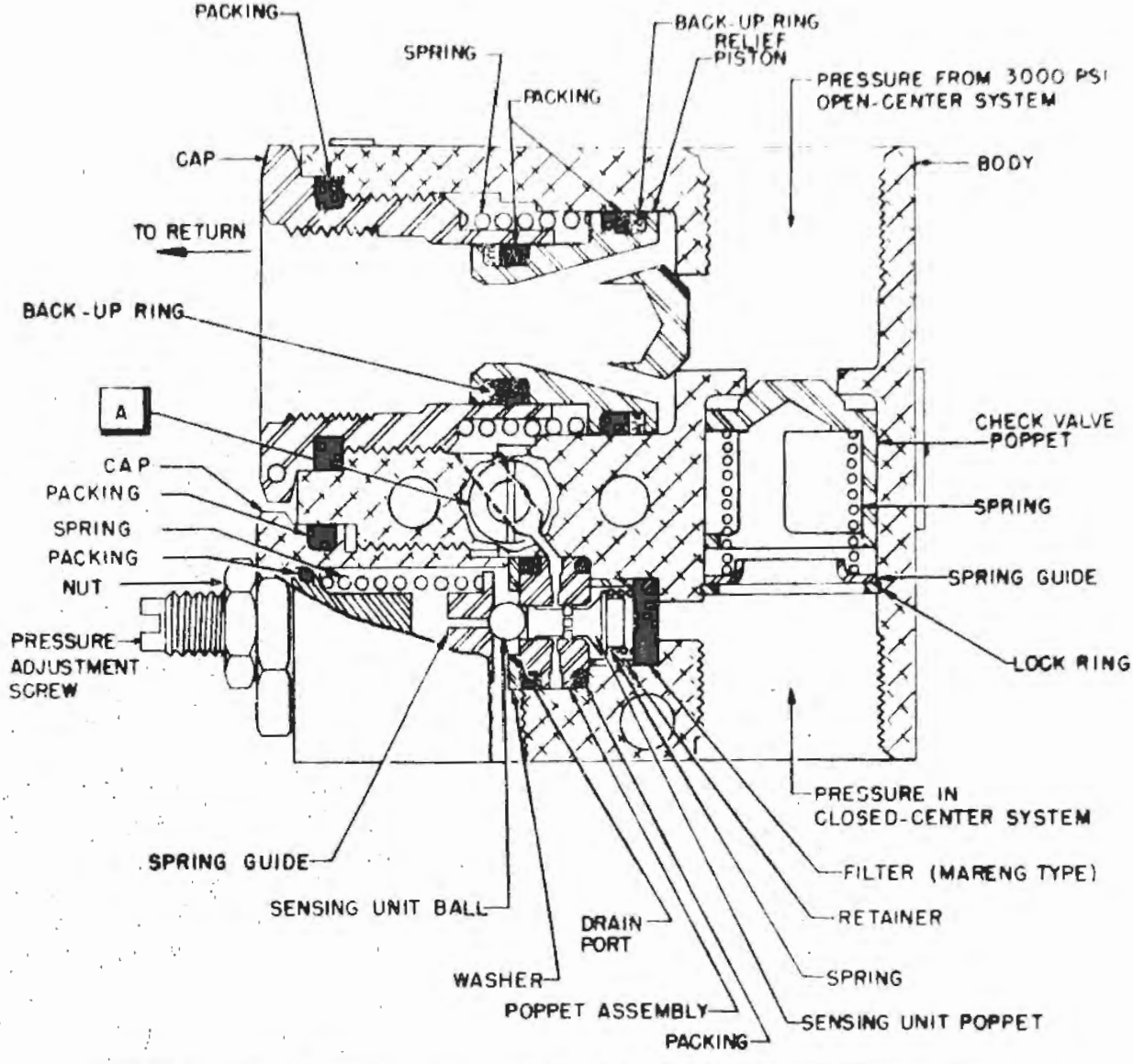


Figure 21. Open Center System Relief Valve



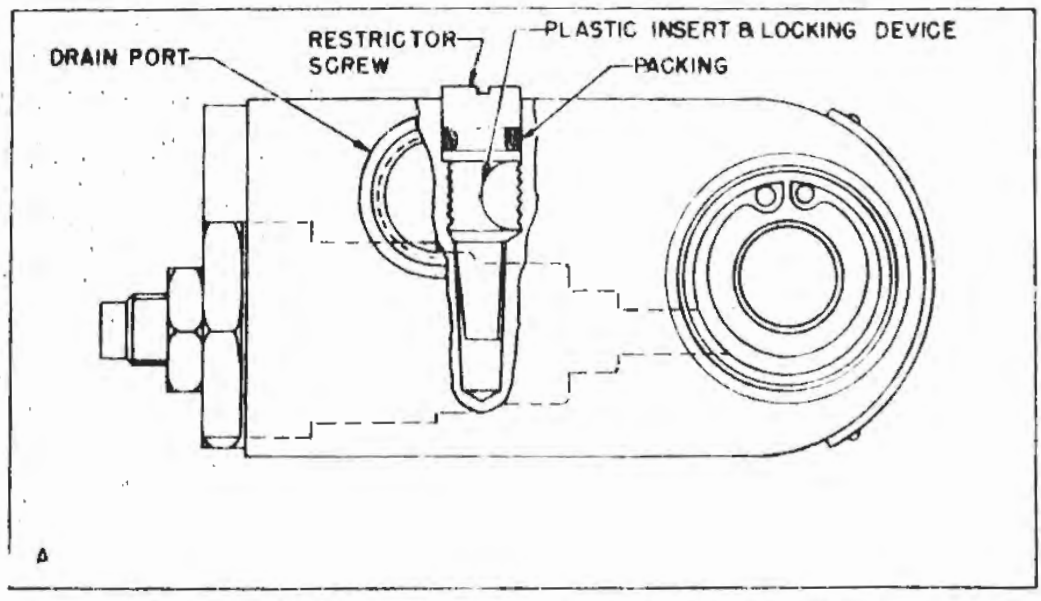
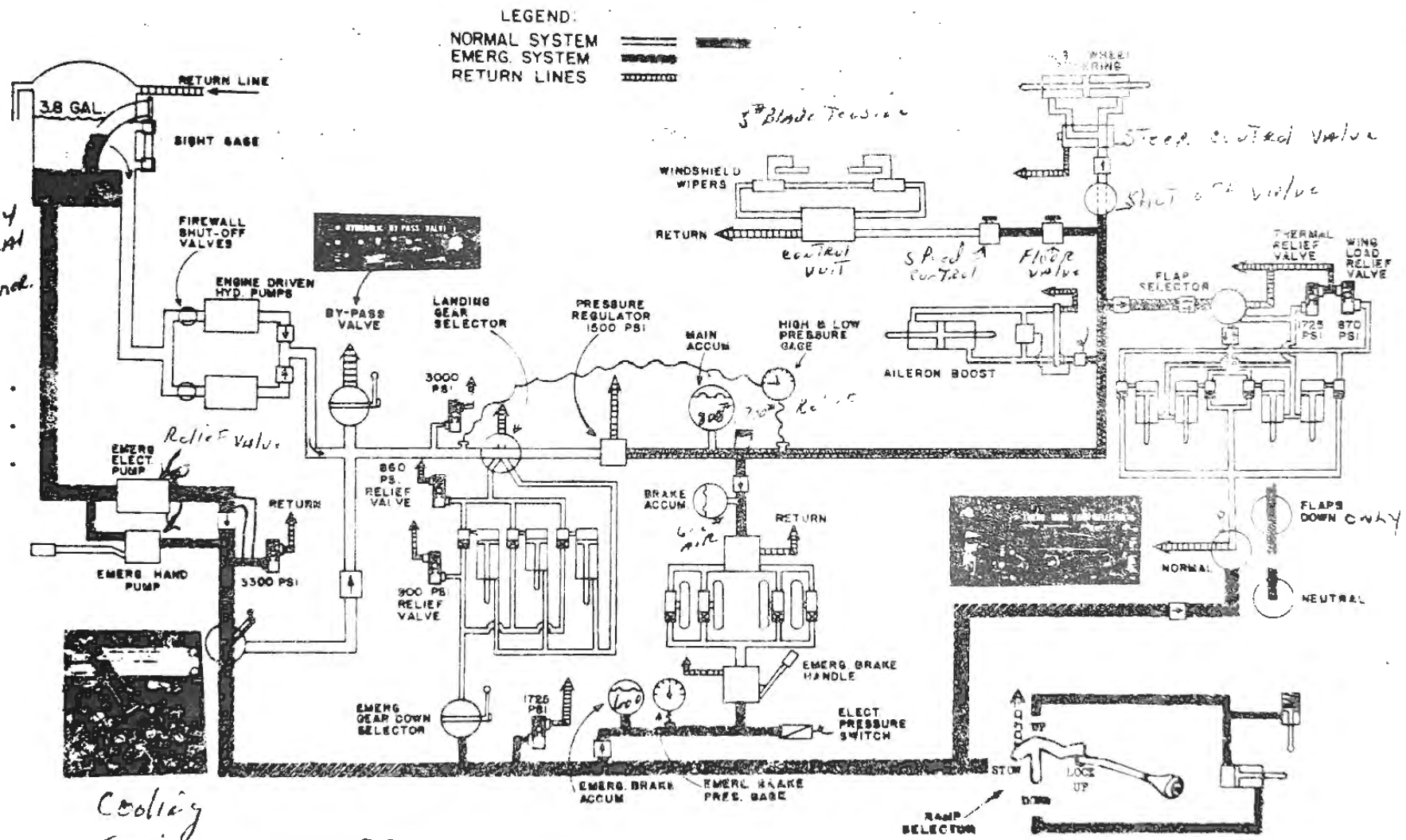


Figure 23. Pressure Regulator Valve

60° Steering each side of Neutral



3rd Blade Tension

Steer. control valve

Shut off valve

Relief Valve

Cooling
5 min on 30 off
1 min on 30 off at 3000

Parking Brakes will bleed Accum press. off in 45 min.

114 gal Engine

NOTE: FORMAT REVISED, PAGES REARRANGED.

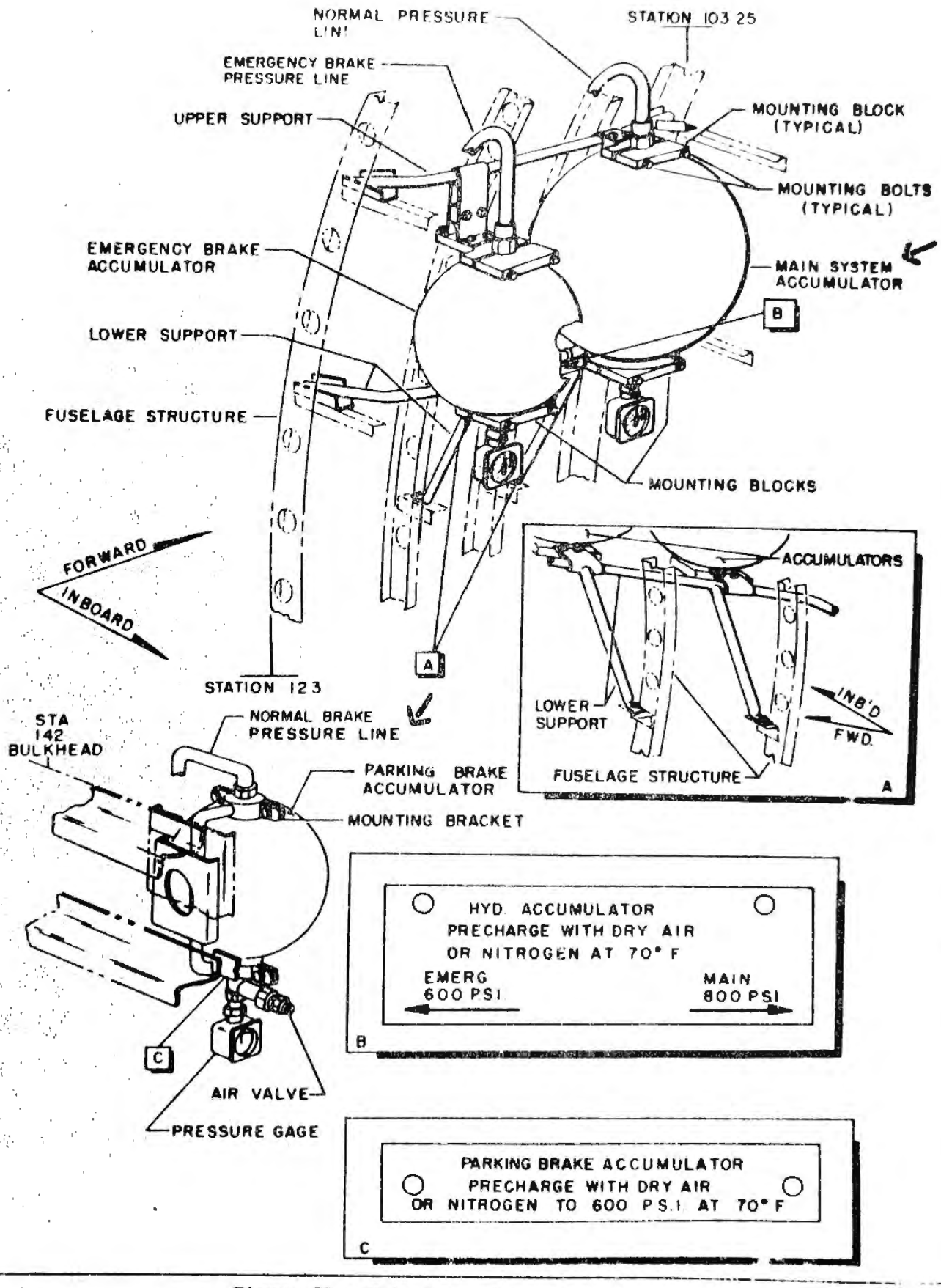


Figure 31. Main Accumulator Installed.

AIR CONDITIONING, HEATING AND VENTILATING - GENERAL (See figure 33).

The cabin pressurization and temperature control systems are designed to provide maximum passenger comfort at either high or low altitude flight operations and at varying outside air temperature conditions.

The cabin pressurization system maintains a pressure altitude within the cabin below the existing altitude at which the airplane is actually flying. In addition, the changes in cabin pressure from one pressure altitude to another can be controlled time-wise in order to provide maximum passenger comfort during ascending or descending flight altitudes. In this manner a suitable atmosphere from the standpoint of pressure is maintained under varying conditions of flight. The temperature control system is designed to maintain cabin temperature within comfortable limits for the passengers and crew by conditioning (heating or cooling) the air being supplied to the fuselage compartments during the following operating conditions.

1. Conditioning (heating) of the air during pressurization.
2. Conditioning (heating) of the air during auxiliary ventilation (unpressurized) flight operation.
3. Heating of the air, without the use of the ground air conditioner, while the airplane is on the ground with engines off.
4. Cooling of the air while operating with right engine running and while taxiing the airplane.

The pressurized portion of the airplane includes all crew, passenger, galley, lavatory, cargo and equipment compartments contained within the fuselage structure. This area incorporates suitable ducts, regulating valves, and equipment to control air temperature, flow, and pressure as desired.

TEMPERATURE CONTROL SYSTEM OPERATION AND VENTILATING AIRFLOW (See figure 33).

Fresh air is supplied to the fuselage distribution system from the engine driven compressor or through a fuselage ram air scoop.

Air flowing from the cabin compressor is heated by process of compression. This air will be used for heating purposes or routed through a cooling system for cooling purposes. If additional heat is required, recirculated cabin air or air picked up through the fuselage ram air scoop may be routed through two intensal combustion heaters and heated before entering the fuselage distribution system. By the foregoing brief description it may be visualized that conditioning (heating or cooling) of the air supplied to the fuselage distribution ducts is achieved by diverting air flow through a cooling or heating system. This action is controlled automatically or manually by the positioning of electric motor driven valves according to the dictates of the temperature control system in maintaining the fuselage compartment temperature at the selected value.

Air flow is further controlled to create the conditions necessary to permit operating the airplane under pressurized, auxiliary ventilation (unpressurized) and taxi cooling conditions. These conditions are achieved by controlling the overboard dumping of cabin air and the air flow entering the fuselage ram airscoop through the positioning of electric motor actuated valves. Operation of the valves is controlled by the manual positioning of the "Air Flow Selector" switch on the pilots' overhead switch panel.

It is adviseable to trace the "flow of air" through the system from its source until it leaves the cabin in order to fully understand the operation of the systems. It is suggested that each of the following conditions given be studied with its respective schematic diagram.

Flight Auxiliary Ventilation (See figure 35). (Primary Compressor Disconnected)

Set up a switch configuration as follows:

"REGULATOR JACKS" - - - - - - - - - "OPEN"
"CABIN HEATING" - - - - - - - - - - -"OFF"
"AIR FLOW SELECTOR" - - -"FLT.AUX.VENT."
"VENTILATING FAN" - - - - - - - - - - "ON"

With a switch configuration as above, "E" valve will be closed, "D" valve will be open, the cabin pressure safety valve, the master and auxiliary cabin pressure regulator valves and jacks will be open. Ram air is drawn in through the secondary heat exchanger ram airscoop. This air enters the plenum chamber and is forced into the hat rack risers and forward to the cockpit. The cockpit has manual controls and the cabin has individual eye ball vents plus ventilating grilles in the crown duct riser.

Pressurized Flight-Full Refrigeration.
(See figure 37)

Set up a switch configuration as follows:

"PRIMARY COMPRESSOR POWER"- - "HIGH"
"PRIMARY COMPRESSOR DISCONNECT" -"AUTO"
"REGULATOR JACK" - - - - - - - "NORMAL"
"CABIN PRESS. REGULATOR"- - - -"NORMAL"
"AIR FLOW SELECTOR"- - - - -"PRESS FLT"
"CABIN HEATING"- - - - - - - - - -"OFF"
"VENTILATING FAN" - - - - - - - - -"ON"

With the "CABIN RATE OF CHANGE" selector set to the desired rate and "CABIN ALTITUDE" selector set to the desired cabin altitude and a switch configuration as above, "D" valve and "G" valve will be closed and "E" valve will be open. The pressure regulators will be controlled by the pressure regulation controls as outlined under "CABIN PRESSURE CONTROLS"

Ram air enters the compressor through the scoop on the right hand wing leading edge. Assuming that the cabin temperature controls are demanding full refrigeration, valve "H" will be closed. The air then goes through the secondary compressor (or the pressure ratio control valve), secondary heat exchanger, expansion turbine and thence through the water separator. From the water separator, the air is directed to the crown duct riser, face vent riser and to the pilot's and co-pilot's outlets. Re-circulated cabin air is returned to the plenum chamber through valve "E". The ventilating fans force the air through to the hat rack risers and to the cockpit. Ram air entering the secondary heat exchanger air scoop is discharged overboard through a louver type valve. It is suggested that this condition be studied in conjuction with "Pressurized Flight-Full Heat"

Pressurized Flight Heat (See figure 39).

Set up a switch configuration as follows:

"PRIMARY COMPRESSOR POWER" - - - -"HIGH"
"PRIMARY COMPRESSOR DISCONNECT" - "AUTO"
"REGULATOR JACK"- - - - - - - - -"NORMAL"
"CABIN PRESS. REGULATOR" - - - -"NORMAL"
"AIR FLOW SELECTOR"- - - - "PRESS. FLT"
"VENTILATING FAN"- - - - - - - - - "ON"
"CABIN HEATING"
"IGNITION" - - - "COIL 1" or "COIL 2"
"FUEL SELECTION"- - - - - "L" or "R"
"CONTROL" - - - - - - - - - - - "AUTO"

With the "CABIN RATE OF CHANGE" selector set to the desired rate and "CABIN ALTITUDE" selector set to the desired cabin altitude and a switch configuration as above, "D" valve, and "G" valve will be closed, "H" valve and "E" valve will be open. The pressure regulators will be controlled by the pressure regulation controls as outlined under "CABIN PRESSURE CONTROLS".

Ram air enters the compressor through the scoop on the right hand wing leading edge. Since "H" valve is open (on a demand for full heat), the air discharges directly into the belly, enters the plenum chanber through "E" valve, passes through the heaters and enters the cabin through the hat rack risers. Mixed air, that is, air from the heaters and re-circulated cabin air, goes to the cockpit where its distribution can be manually controlled.

NOTE

This condition is somewhat hypothetical. Actually, some air would normally pass through the cooling system to be available at the face vents. The condition is presented in its present form to isolate the heating channels for better understanding. It is suggested that this condition be studied in conjunction with "Pressurized Flight-Full Refrigeration" to help to understand any intermediate conditions.

Taxi Cooling (See figure 41).

Set up a switch configuration as follows:

"PRIMARY COMPRESSOR POWER" - - "HIGH"
"PRIMARY COMPRESSOR DISCONNECT" -"AUTO"
"CABIN PRESS. REGULATOR"- - - -"NORMAL"
"REGULATOR JACK" - - - - - - - "NORMAL"
"CABIN HEATING" - - - - - - - - - "OFF"
"AIR FLOW SELECTOR" - - -"TAXI COOLING"
"VENTILATING FAN" - - - - - - BOTH "ON"

With a switch configuration as above, "D" valve and "G" valve will be open and "E" valve will be closed.

Ram air enters the compressor through the scoop on the right hand wing leading edge. Assuming that the cabin is not demanding heat, valve "H" is therefore, closed and the air goes to the secondary compressor or through the pressure ratio control valve. The air then goes through the secondary heat exchanger and expansion turbine. The cool air passes through the water separator into the crown duct riser, the face vent riser and to the cockpit. Ram air is also induced through the secondary heat exchanger by the ventilating fans. Since "D" valve is open, this air is forced through the plenum chamber and discharged overboard through valve "G".

Recirculation Air Flow (See figure 33).

Cabin air is drawn from the cabin by the recirculation blowers through a floor level grille below the carry-on baggage rack and the aft coat room floor grille. The air flows forward through the belly and around the cargo compartment to the vicinity of the heaters. At this point, it enters the plenum chamber and then the two blowers. Two heater-blower circuits are arranged in parallel. In either circuit, part of the air passes through the heaters where it is heated while the rest of the air by-passes the heater, the proportion of air in heater and by-pass being controlled by the mixing valve to produce the selected cabin temperatures. The mixed warm air is delivered to the hot air hat rack from which it is distributed to the warm wall outlets, the window defogging outlet, the under seat anemostats, the lavatory heat, and galley heat. Mixed hot air and recirculated air are also furnished to the cockpit from the heaters for cockpit heat, windshield anti-icing and defogging.

Windshield air is returned to the belly through wall ducts just aft of station 212. Cockpit air is routed to the galley through a grille in the pilots' compartment door. This air, along with galley return air is returned to the belly through wall ducts on the right hand side of the fuselage between stations 255 and 272. Cabin air is returned to the belly through the recirculation air grille beneath the carry-on baggage rack and aft coat room floor grille.

WARNING

If an outer cabin window should fail during pressurized flight, the airplane shall be immediately de-pressurized and not again be flown pressurized until not only the outer window but also the inner cabin window and reveal have been replaced with new parts.

1. VENTILATING FAN

Two ON-OFF switches control ventilating operation and airflow over the heater. The respective fan must be ON to operate the cabin heater on that side as electric power for heater operation is available only when the fan switch is ON.

2. COMBUSTION BLOWER LIGHTS

Two amber lights which when lit indicate when the combustion blower is operating. Combustion blowers are not required in flight. Following take-off when in-flight ram air is sufficient for heater operation it will be necessary to momentarily turn OFF the ventilating fan switch to de-energize the combustion blower.

3. AIR FLOW SELECTOR

A three-position switch to control the positioning of all dampers, valves, pressure regulator, safety valve and regulator jacks which control airflow routing. The three positions are:

a. FLIGHT AUXILIARY VENTILATION

b. PRESS FLT - GRD HEAT - ENGINES OFF

c. TAXI-COOLING

FLT AUX VENT position will always be used if the compressor is DISCONNECTED or during emergency conditions. When in this position air exhausts through the two outflow and the two safety valves.

TAXI-COOLING position is for ground refrigeration. If it is to be used, place compressor power switch to the high position, turn on BOTH ventilating fans and the monitored bus. Generator operation should be monitored since the left ventilating fan will stop if either generator fails.

PRESS FLT will always be used in flight for pressurization and/or refrigeration.

As heat is required on the ground when the engines are inoperative there are two possible airflow conditions. One is when the Airflow Selector is set to the PRESS FLIGHT position which does not introduce fresh air into the cabin but utilizes the recirculating air circuit. The other condition does not use recirculated air, but brings fresh air into the cabin through the Flight Auxiliary Ventilation airscoop. Obviously the latter condition occurs when the Airflow Selector switch is set to FLT AUX VENT.

If the ground air conditioner attachment connection (accessible in the first belly hatch) is used, it makes little difference where the Airflow Selector is positioned, but do not operate either vent fan.

During pressurized flight if the Airflow Selector Switch is placed in TAXI-COOLING or FLIGHT AUX VENT, CABIN DIFFERENTIAL PRESSURE IS DUMPED IMMEDIATELY. Depressurize before switching to Flt Aux Vent.

4. HEATER CONTROL SWITCHES

Two three-position switches, MANUAL, OFF and AUTO. In the MANUAL position, the heater cycles on and off maintaining discharge air temperature of 127°C. In the AUTO position the heater operates subject to the automatic thermostat requirements. Thermostat control will be overridden and the heater(s) turned ON will operate as in MANUAL whenever the WINDSHIELD ANTI-ICE control located on the First Officer's side wall is pulled UP.

The cabin heater may be operated in AUTOMATIC any time on the ground with engines not running except during fueling operations, providing a pilot or mechanic remains in the cockpit to monitor heater operations.

To operate the cabin heaters, turn ON the vent fans, Heater Switches in AUTOMATIC, select fuel to LEFT or RIGHT carburetor and turn on boost pump on that side if the engines are not running.

Operating a cabin heater in MANUAL when the cabin is not calling for heater operation will result in an overheating heater unless an outlet for heated air is provided by pulling UP windshield ANTI-ICE control or by pulling UP pilot heat controls.

Do not operate cabin heaters when Airflow Selector Switch is set to TAXI-COOLING as heated air would be dumped overboard immediately, if the thermostat is calling for heat and, if not, there is no ventilating airflow over the heater.

5. HEATER OVERHEAT WARNING LIGHTS

Each cabin heater has a red overheat light which comes ON and remains lit following a failure of both of the 127°C cycling switches. The heater will be shut off automatically and "lock-out" when the heater discharge air reaches 177°C. In order to re-start a heater following an overheat warning, reset the overheat relay by turning the heater OFF and back to ON. Do not attempt to re-start a "tripped" heater if the cabin heater temperature gauge indicates an overheating condition at the time the heater locks out. If the heater temperature does not decrease after the overheat light comes on, turn OFF the Fuel Selection Switch to cut the fuel to both heaters in the event the heater is overheating due to the cycling solenoid sticking open.

A heater temperature above 130°C should be considered as an overheating heater.

There are no fenwall fire warning switches in the heater duct downstream from the heaters; however, overheat warning will be available from the cabin heater temperature gauge and/or the overheat warning light.

6. Fuel To Either Or Both Cabin Heaters will be available whenever the cabin heater CO_2 selector control is IN and the cabin heater fuel selector switch is turned to the right or left engine carburetor having fuel under pressure by the engine driven pump or the auxiliary boost pump.

Fuel Selection - is a three-position switch - LEFT, OFF, and RIGHT. When ON this switch energizes the left or right fuel transfer valve to the cabin heater fuel system. This provides fuel under pressure up to the individual cabin heater fuel cycling valve whenever pressure exists at the carburetor selected. To operate either or both cabin heaters on the ground with engines OFF turn on either boost pump and actuate Fuel Selection to that side.

7. FUEL FAILURE

One red fuel failure light comes on when the fuel pressure to the cabin heater fuel system falls to less than 8 PSI. If the light comes ON steady in flight it indicates that a low pressure condition exists.

If the right cabin heater is operating when the FUEL FAILURE light glows while in flight, switch FUEL SELECTION to obtain fuel pressure from the opposite carburetor. If FUEL FAILURE light still glows, turn off right cabin heater and turn on left heater. If light still glows, turn off left cabin heater and FUEL SELECTION switch. A leak is common to either fuel source and both heaters.

The cabin heater fuel fail light, and possibly the engine fuel pressure warning light may blink on when the heater(s) call for fuel.

8. CABIN HEATER CYCLING LIGHTS

One green light for each heater indicates when the heater is operating, that is, when fuel flow to the heater is required. If fuel pressure is normal the heater temperature gauge should indicate heater operation when the green cycling lights are lit. If the heater(s) is not operating, it is probably caused by faulty ignition.

CABIN HEATER IGNITION SWITCHES

One two-position selector switch for each heater allows selection of reserve ignition points in case of failure of the normal set of points. When heater switch is ON ignition occurs continuously.

In flight a cabin heater green cycling light remains lit continuously. Fuel selection is made. Fuel fail and overheat lights are not lit. This indicates that fuel is flowing normally to the heater but the ignition has failed. Before selecting the opposite ignition points, turn the heater OFF for one minute to allow the excess fuel in the combustion chamber to evaporate.

An Automatic Cut-Off Relay - is provided which automatically de-energizes both heaters, both combustion blowers and both recirculating fans whenever the cabin heater compartment fire extinguisher selector is pulled and/or when the battery alone is on the bus.

11. COMPRESSOR POWER

A two-position switch placarded LOW and HIGH permits lowering the compressor power absorbed from the right engine from a maximum of 85 to 34 hp during engine starting, ground operation except TAXI COOLING, take-off and landing or when power failure has occurred on left engine.

The only time the compressor is drawing maximum power from the engine is when refrigeration is occurring.

In the HIGH power position the compressor maintains a constant airflow output of about 70 pounds of air per minute. In the LOW power position the compressor is operating in a minimum air flow condition.

Refrigeration and/or full pressurization is obtainable only when operating in the HIGH power or maximum air flow condition. After take-off, switch to HIGH power.

Place Compressor Power Switch in LOW position prior to shifting airflow Selector from one position to another or prior to disconnecting compressor from engine.

No airflow will pass over the secondary heat exchanger if the Airflow Selector is placed in the PRESSURIZED FLIGHT position when the airplane is on the ground and calling for refrigeration. If the compressor is operated in HIGH power in this configuration, the expansion turbine inlet temperature will be high and the turbine will overheat, smoke and may fail.

The secondary compressor and expansion turbine would also overheat and fail if the compressor is operated in HIGH power in TAXI-COOL if both Vent Fans are not on whenever calling for refrigeration.

Before landing if the compressor will not shift to LOW power, place Air Flow Selector in TAXI-COOL if refrigeration is required, and if not, FLT AUX VENT and turn on both vent fans.

12. COMPRESSOR DISCONNECT SWITCH

Labeled MAN and AUTO. When placed in the MAN position the electrical circuit is closed to energize a solenoid which disconnects the compressor from the right engine which causes the compressor to lock out mechanically until reset on ground.

Before disconnecting, place compressor power switch to the LOW position. When disconnecting, the engine RPM should be at least 1900.

The compressor will automatically disconnect in flight only whenever the left propeller automatically feathers.

13. COMPRESSOR OIL PRESSURE GAUGE

Indicates compressor oil pressure which should normally be about 80 PSI. The operating range is from 60 to 110 PSI. Disconnect the compressor if the oil pressure drops appreciably below 60 PSI or if it fluctuates abnormally.

As the throttle is advanced from the idle position the compressor oil pressure will normally increase until the engine RPM reaches about 1200, then the pressure drops about 10-15 PSI as the compressor automatically shifts gears from HIGH ratio back to LOW ratio. As the throttle is further advanced the oil pressure again increases slowly with engine RPM change.

As engine RPM is then decreased the compressor oil pressure will decrease with decreasing engine speed. Upon reaching about 800-900 RPM the compressor will automatically shift back to HIGH gear ratio to provide high drive shaft speeds necessary when engine speed is low as is required during TAXI COOLING operations.

14. COMPRESSOR OIL PRESSURE WARNING LIGHT

Red light indicates when compressor oil pressure is abnormally low and will glow when the oil pressure drops to about 42 PSI. This is the only A.C. powered warning light on the airplane.

15. COMPRESSOR OIL TEMPERATURE GAUGE

Although oil temperature regulation is automatic, maximum permissible oil temperature is 107°C.

16. MANIFOLD (DUCT) PRESSURE GAUGE

The manifold pressure gauge indicates compressor pressure differential between suction and discharge side of compressor. The inlet or intake static pressure is indicated on the "I" pointer indicator and the compressor discharge static pressure is indicated on the "D" pointer indicator. When the engine is not running, the "I" and "D" pointers both should indicate station barometric pressure.

The greater the spread between the I and D pointer, the greater the load on the compressor. That is, when there is a large back load on the compressor, as is the case when refrigerating, the D and I pointer spread will be large indicating the compressor is operating at a high speed to maintain a constant air flow of 70 pounds of air per minute.

When not refrigerating but operating under full pressurization, the spread between the D and I pointer will be about 7" HG.

When not refrigerating or depressurized the spread between the D and I pointer may be only 1-2" HG when in HIGH power. Less spread exists when in LOW power.

The maximum permissible spread between the D and I pointer is expressed in terms of the ratio between D to I which is 1.9 to 1, that is, D may be 1.9 times higher than I. A ratio of more than 1.9 to 1 or 2 to 1 may be caused by a faulty pressure ratio control valve causing the impeller to overspeed. In such a case it would be a function of the compressor governor to limit the impeller speed to 40,000 RPM.

When flying at an airplane altitude of 7000 feet or higher it is normal for the compressor to operate at a differential of 1.9 to 1 when refrigerating.

Prior to starting the right engine check the D and I pointer readings and if they are not the same, note the existing spread so an allowance can be made for this fact when checking compressor D to I spread while in flight.

16. MANIFOLD (DUCT) PRESSURE GAUGE

"I" pointer reading generally indicates about atmospheric pressure. When refrigeration is called for, "I" remains the same but D pointer increases steadily and the refrigerator "Air Temperature" steadily decreases. If High D pointer readings are not associated with relatively low refrigerator Air Temperatures or if D pointer readings are erratic, switch to LOW power and DISCONNECT.

Anytime the compressor is disconnected give a detailed description in the log book to assist Maintenance in locating the faulty unit(s).

17. REFRIGERATOR AIR TEMPERATURE INDICATOR

Measures temperature of air between expansion turbine and water separator and indicates relatively low when the cabin is "refrigerating". When the compressor is disconnected or the right engine is not running, cabin heater air may back up in the ducts and indicate an abnormally high temperature on this gauge.

18. CABIN ALTITUDE RATE OF CHANGE INDICATOR

Senses cabin altitude rate of climb or descent. Indicator is vented to cabin static pressure.

19. CABIN ALTITUDE AND DIFFERENTIAL PRESSURE INDICATOR

Indicates airplane and cabin altitude pressure differential. Measurement is between cabin and nose wheel well. "A" pointer indicates airplane pressure altitude. "C" pointer indicates cabin pressure altitude The greater the spread between the two pointers, the greater the differential pressure. The "differential pressure" side of the pointers is calibrated in PSI.

"Maximum differential" pressure is 6" HG or 3 PSI. MANUALLY DEPRESSURIZE if the differential pressure exceeds this value.

The "A" and "C" pointers will indicate the same when the airplane is unpressurized. On the ground the reading on the "A" and "C" pointers will correspond to the existing local "pressure" altitude.

20. PRESSURE "REGULATOR JACK" SWITCH

Is a three-position switch - NORMAL OFF and OPEN. When in the NORMAL position the outflow valve will be opened or closed depending upon the position of the airflow Selector Switch. When in the OPEN position the outflow valves will be opened and held open by the regulator jack screw. Also when landing, the left gear scissor switch automatically dumps the remaining cabin pressure differential if the airplane is not fully depressurized.

Regulator Jack Switch may be in either NORMAL or OPEN position in all flight conditions except PRESS FLIGHT. When in PRESS FLIGHT condition if Jack Switch is placed in OPEN position, CABIN DIFFERENTIAL PRESSURE IS DUMPED IN 30 SECONDS.

21. PRESSURE REGULATOR SWITCH

This is a three-position switch - NORMAL, OFF and RESET. When in the NORMAL position, the pressure regulator maintains cabin pressure as selected by the pilot whenever the airplane is in flight and the Airflow Selector Switch is set to PRESS Flt. When in the RESET position the pressure regulator control chamber unit is reset to the altitude selected on the cabin altitude selector. The RESET position bypasses the rate of change selector and the control chamber of the pressure regulator is rapidly reset to the new altitude called for on the altitude selector.

22. RATE OF CHANGE SELECTOR

[illegible] altitude rate of [illegible] up the desired climb or descent [illegible] set to a certain position, such [illegible] pressure regulator [illegible] trol chamber will [illegible] per minute until the [illegible] tude selected on [illegible] to the rate [illegible] whenever the airplane is at less than 9,3[illegible] 400 feet or when the ground test switch is in the up position. Power from the Forward Distribution Bus is required for this circuit.

23. CABIN ALTITUDE SELECTOR

Cabin altitude selector permits control of the pressure regulator. When selecting a particular altitude when pressurized, the pressure regulator changes at the rate called for on the Rate of Change selector.

Before take-off and prior to landing, it is important to set the cabin pressure regulator using local "pressure" altitude instead of arbitrarily using airport elevation.

A recommended procedure for setting the cabin altitude selector prior to departure is to first obtain the "pressure altitude" from the "A" and "C" pointer cabin altimeter. Adjust the cabin altitude selector to this altitude, adding about 200 feet to allow for calibration error. Place the pressure regulator switch to RESET, then after the RESET light goes out, place the switch back to NORMAL. This selection adjusts the cabin pressure regulator to the pressure altitude where the regulator will automatically close the cabin after take-off.

Once the regulator switch has been returned to NORMAL (prior to departure) the cabin altitude selector can again be adjusted without disturbing the pressure altitude previously RESET. Determine and set the cabin altitude that is desired for cruise. This is the altitude at which the pressure regulator will automatically regulate the cabin.

Electrical power from the Forward Distribution Bus is required for this circuit.

Compare actual cabin altitude with Cabin Altitude Selector on first leg of the flight to determine cabin altitude selector error and adjust the calibration scale if required. When the need for calibration is indicated the dial may be rotated a few degrees in order to make the selected altitude agree with the actual cabin altitude as indicated on the cabin altimeter. Calibration by the pilot is occassionally required account slight variations in electrical and mechanical controls in cabin altitude selector and pressure regulator.

Never re-adjust the calibration scale when near maximum pressure differential due to the possibility of excessive cabin air leaks preventing the pressure regulator from controlling the cabin altitude.

24. PRESSURE REGULATOR RESET LIGHT

The pressure regulator altitude reset light comes on when the pressure regulator switch is placed in the reset position and remains on until the regulator is reset to the selected altitude. If the light does not come on when the switch is in the RESET position it indicates that the pressure regulator is already set to the altitude selected on the cabin altitude selector. If this occurs check "reset" operation by selecting a different setting.

25. COCKPIT TEMPERATURE

Cockpit temperature is a push pull control located on the Captain's side wall which controls the position of a valve which regulates the temperature of the air to both pilots. Pilot's "eye ball" or face vents shall always supply cool air.

COCKPIT TEMPERATURE

...right cabin heater provides a more direct hot air- ...to the cockpit and windshield than does the left ... When operating in FLT AUX VENT due to an in- ...tive compressor, operating the left heater in ...TIC provides less hot air to the cockpit than ...operating the right heater alone. Operating ...right Vent Fan with that heater turned off further ...tes the warm air from the left heater to the cock-

...mild weather where refrigeration is required to ...the cabin and not to the cockpit, operating the right ...heater alone is more desirable than operating the ...left as the right heater has more effect on the cock- ...pit than the left. Operating the left vent fan with- ...out the left heater may also be desirable to further ...influence cockpit temperature.

...WINDSHIELD ANTI-ICE

"Windshield Anti-Ice" control is located on the First ...Officer's side wall and regulates the temperature and ...quantity of the air to the main double paned wind- ...shield.

If the cabin heater(s) are operating in AUTOMATIC, pulling UP the ANTI-ICE control causes the heater(s) to operate as in MANUAL.

When in TAXI COOL or during an approach when refrig- erating, WINDSHIELD ANTI-ICE valve should be in the full UP position to counteract any tendency of the windshield to fog. Wait until over the fence on landing to shift to LOW power. Turn on cabin heat- ers if necessary to protect windshield if fogging is anticipated.

27. WINDOW DEFOG

"Window Defog Control" is located on the Co-Pilot's ...side wall. Manual control is used to regulate the ...amount of air blast to the single paned corner wind- ...shields and sliding panels. Airflow for defogging ...side windows can be substantially increased by pulling ...up on "Windshield Anti-Ice" control. The temperature of the air is also increased by the WINDSHIELD ANTI- ICE manual control if the cabin heaters are turned on.

...PILOT HEAT

The "Pilot Heat" controls the airflow through the ...toe grill louvers. Standard installation is to ...pull out for heat.

Sometimes difficulty is experienced in getting heat to the cockpit when the cabin is calling for refrigeration which is more pronounced in some air- planes than others. In some cases the condition reaches a point where it is necessary to trip cir- cuit breaker #62 and crank the thermostat valves counter-clockwise until the desired temperature condition is reached.

...TEMPERATURE CONTROL

Located on the Hostess switch panel, controls the cabin temperature independent of Airflow Selector position. The cabin temperature control ranges from 65°F to 95°F.

The thermostat electrical control system requires about 5-7 minutes to change from full cooling to full heating or vice-versa.

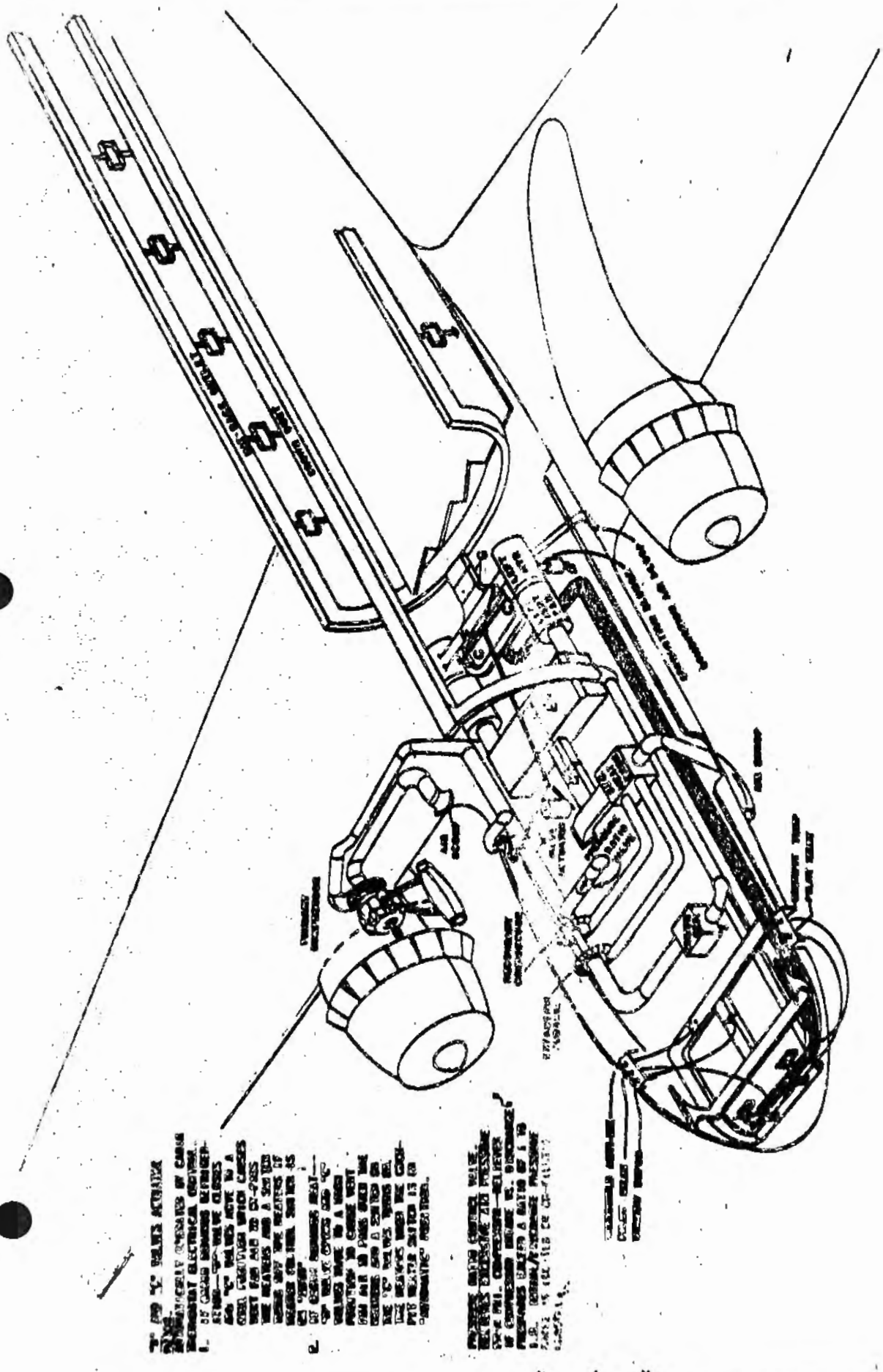
If the cabin thermostat electrical control system fails when the thermostatically controlled cabin valves are in the COOL AIR position, heat can be restored to the cabin by deactivating the thermo- statically controlled motor-driven actuators by tripping circuit breaker #62, CABIN TEMPERATURE CONTROL, and inserting crank in MANUAL HEAT CON- TROL located in companionway floor and turning counter-clockwise to a position providing desired temperature. Crank is stowed above the large circuit breaker panel in the companionway.

In the event of failure of the cabin temperature control system resulting in the cabin running too cool, trip C.B. #62 and crank the Manual Heat Control in the counter-clockwise direction. If the control binds, depressurize and shift the compressor to LOW power to decrease the air load on the "H" valve, then resume cranking of the Manual Heat Control.

About four complete turns are required to move the controls from one extreme position to another.

* * *

G. ILLUSTRATION OF PRESSURIZATION, HEATING AND VENTILATING SYSTEM



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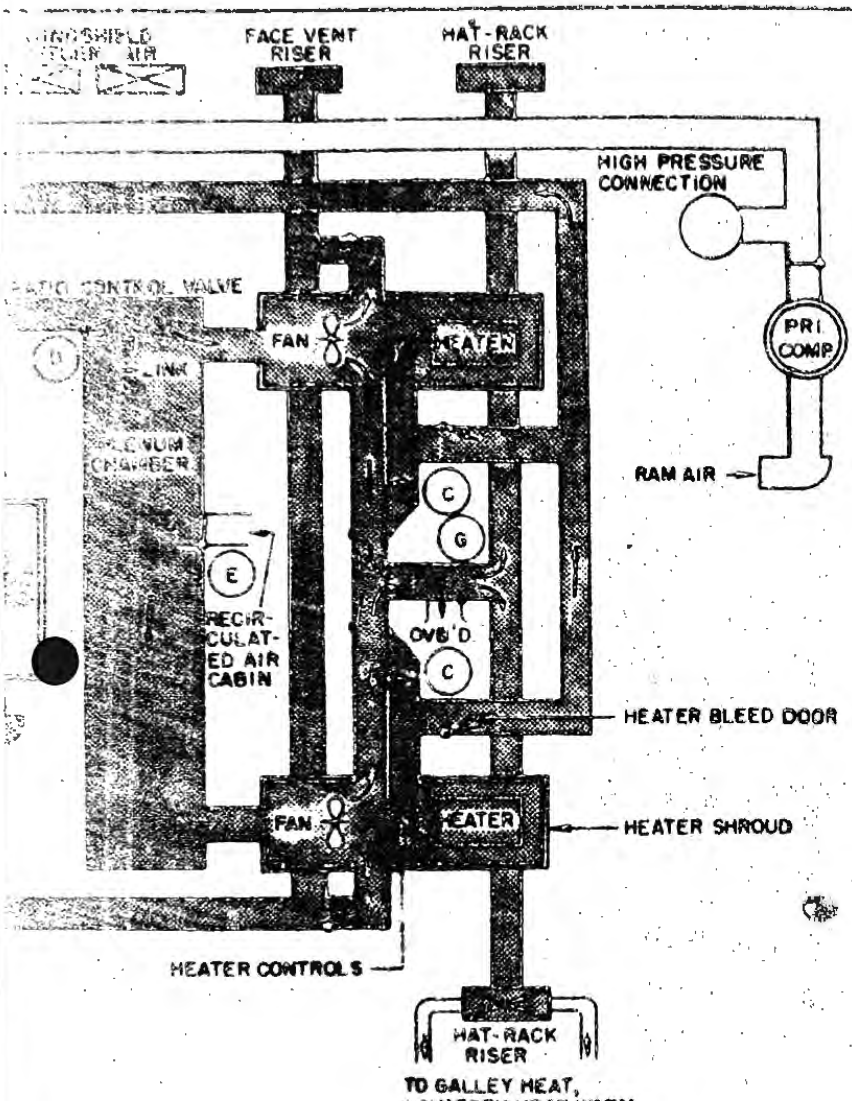


VALVES

- (A) MANUAL - COCKPIT TEMPERATURE
- (B) MANUAL - WINDSHIELD AIR
- (B_1) MANUAL - DEFOGGING AIR
- (B_2) MANUAL - WINDSHIELD BIRDPROOF TEMPERED
- (C) MECHANICAL - OPERATED BY MOTOR IN SEQUENCE WITH VALVE (H) WHEN VALVE (H) CALLS FOR HEAT
- (D), (E) SINGLE MOTOR - DIRECTION VALVES FOR TAXI COOLING AIRFLOW
- (G) MOTOR - DIRECTION VALVE FOR TAXI COOLING AIRFLOW AND VENTILATION OR HEATING WHEN UNPRESSURIZED
- (H) MOTOR - CONTROLLED BY CABIN TEMPERATURE SEQUENCES OPERATION OF VALVES (C)

REFRIGERATED AIR

PARTIALLY COOLED AIR

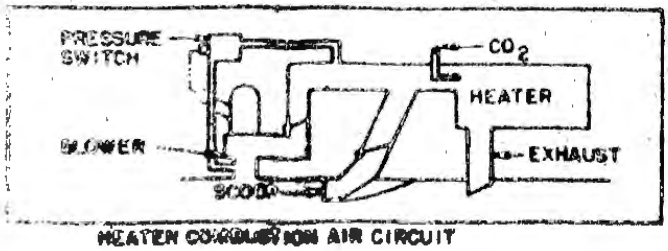
PRESSURIZED AIR

RAM AIR

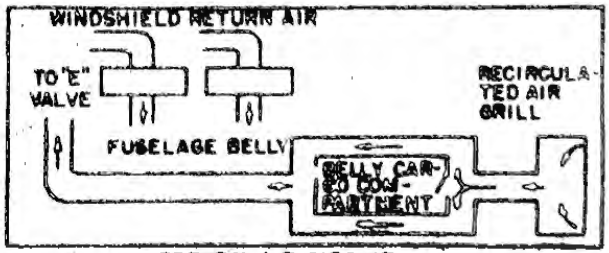
CHECK VALVE

SPRING LOADED RESTRICTOR

BALANCING ORIFICE



HEATER COMBUSTION AIR CIRCUIT



RETURN AIR CIRCUIT

(Sheets) Flight Auxiliary Ventilation Air Flow Schematic

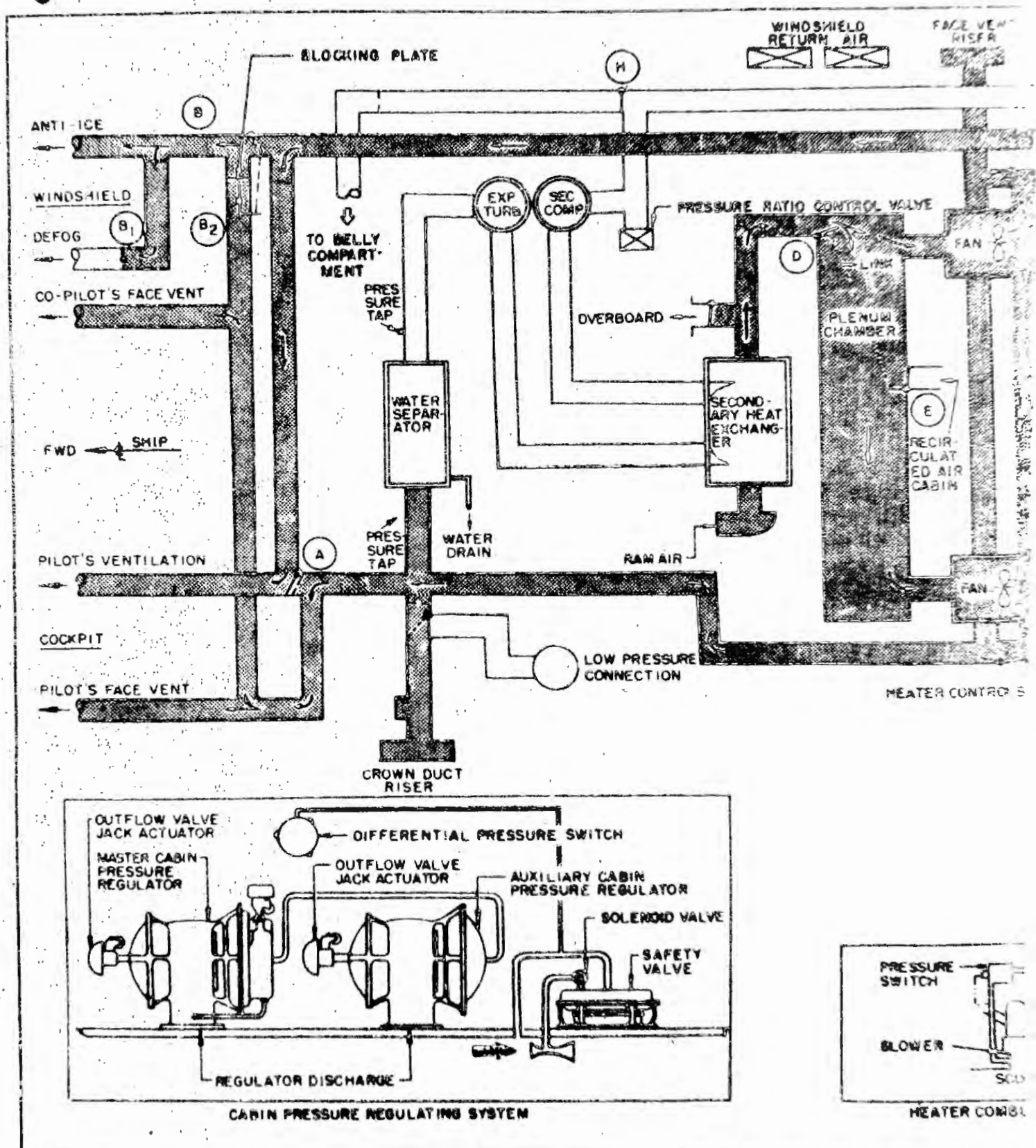


Figure 35. (Sheet 2 of 2 Sheets) Flight Aux

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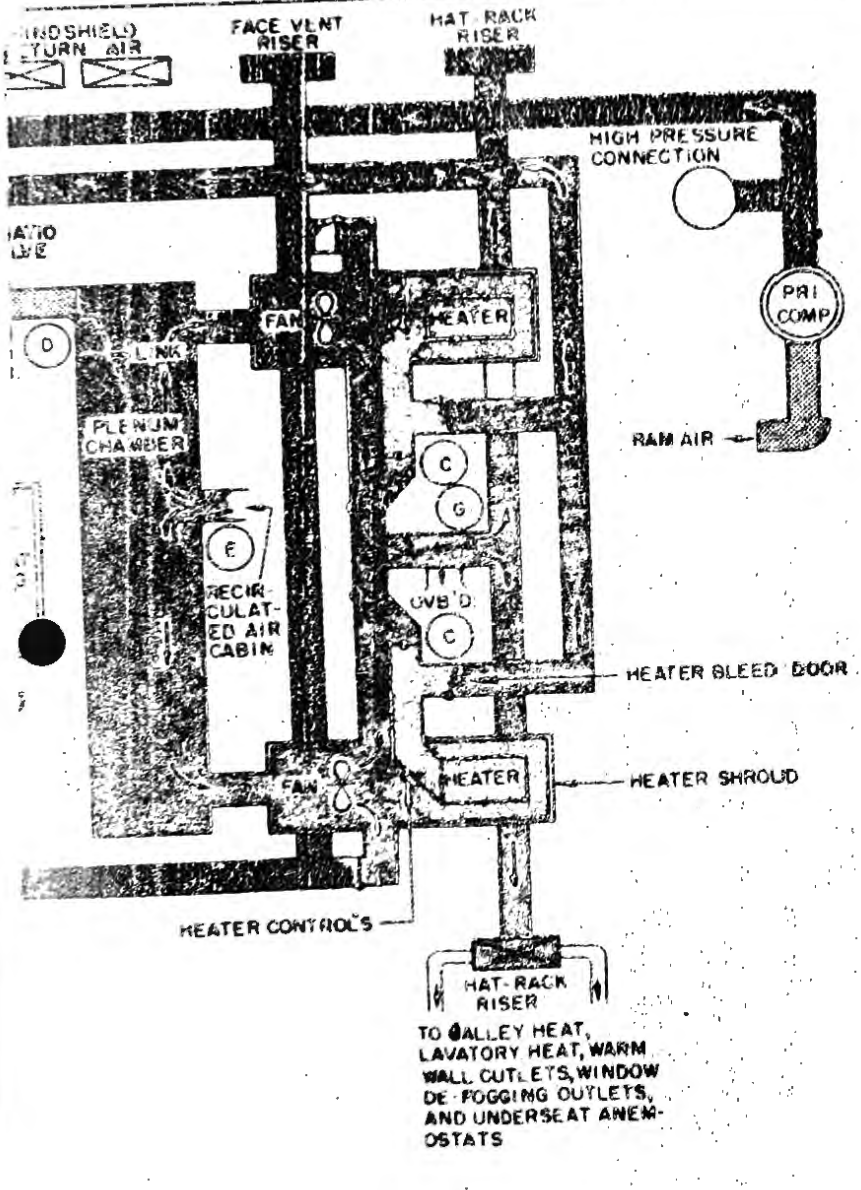


VALVES

- (A) MANUAL - COCKPIT TEMPERATURE
- (B) MANUAL - WINDSHIELD AIR
- (B_1) MANUAL - DEFOGGING AIR
- (B_2) MANUAL - WINDSHIELD BIRDPROOF TEMPERATURE
- (C) MECHANICAL - OPERATED BY MOTOR IN SEQUENCE WITH VALVE (H) WHEN VALVE (H) CALLS FOR HEAT
- (D), (E) SINGLE MOTOR - DIRECTION VALVES FOR TAXI COOLING AIRFLOW
- (G) MOTOR - DIRECTION VALVE FOR TAXI COOLING AIRFLOW AND VENTILATION OR HEATING WHEN UNPRESSURIZED
- (H) MOTOR - CONTROLLED BY CABIN TEMPERATURE SEQUENCES OPERATION OF VALVES (C)

CABIN AIR RETURN

REFRIGERATED AIR

PARTIALLY COOLED AIR

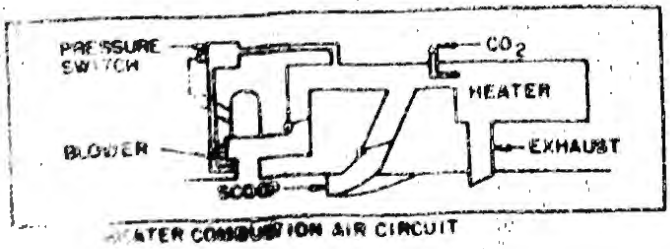
PRESSURIZED AIR

RAM AIR

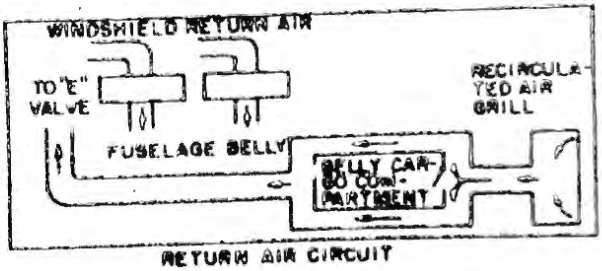
CHECK VALVE

SPRING LOADED RESTRICTOR

BALANCING ORIFICE



HEATER COMBUSTION AIR CIRCUIT



RETURN AIR CIRCUIT

(Sheet 3) Pressurized Flight Full Refrigeration Air Flow Schematic

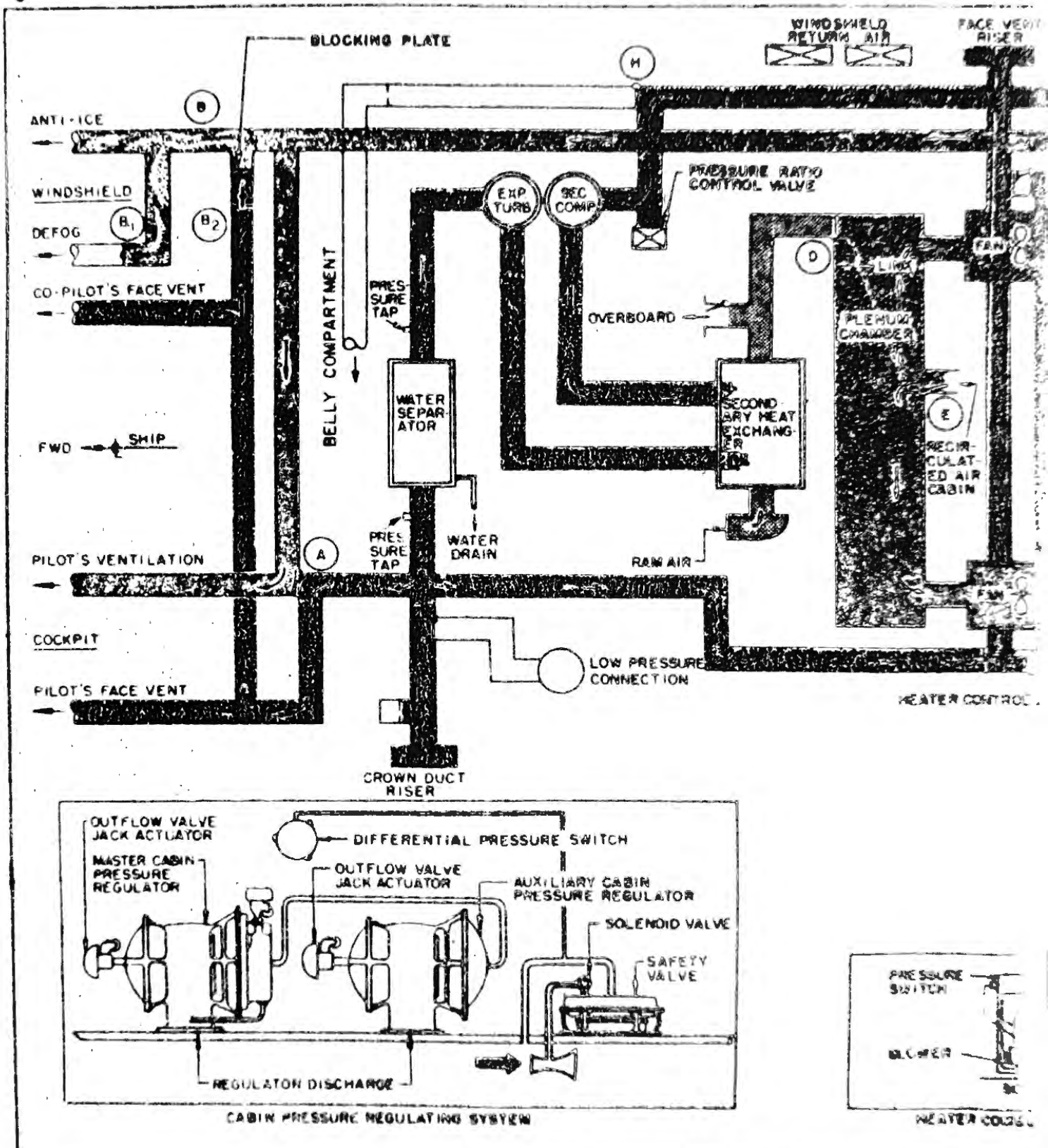
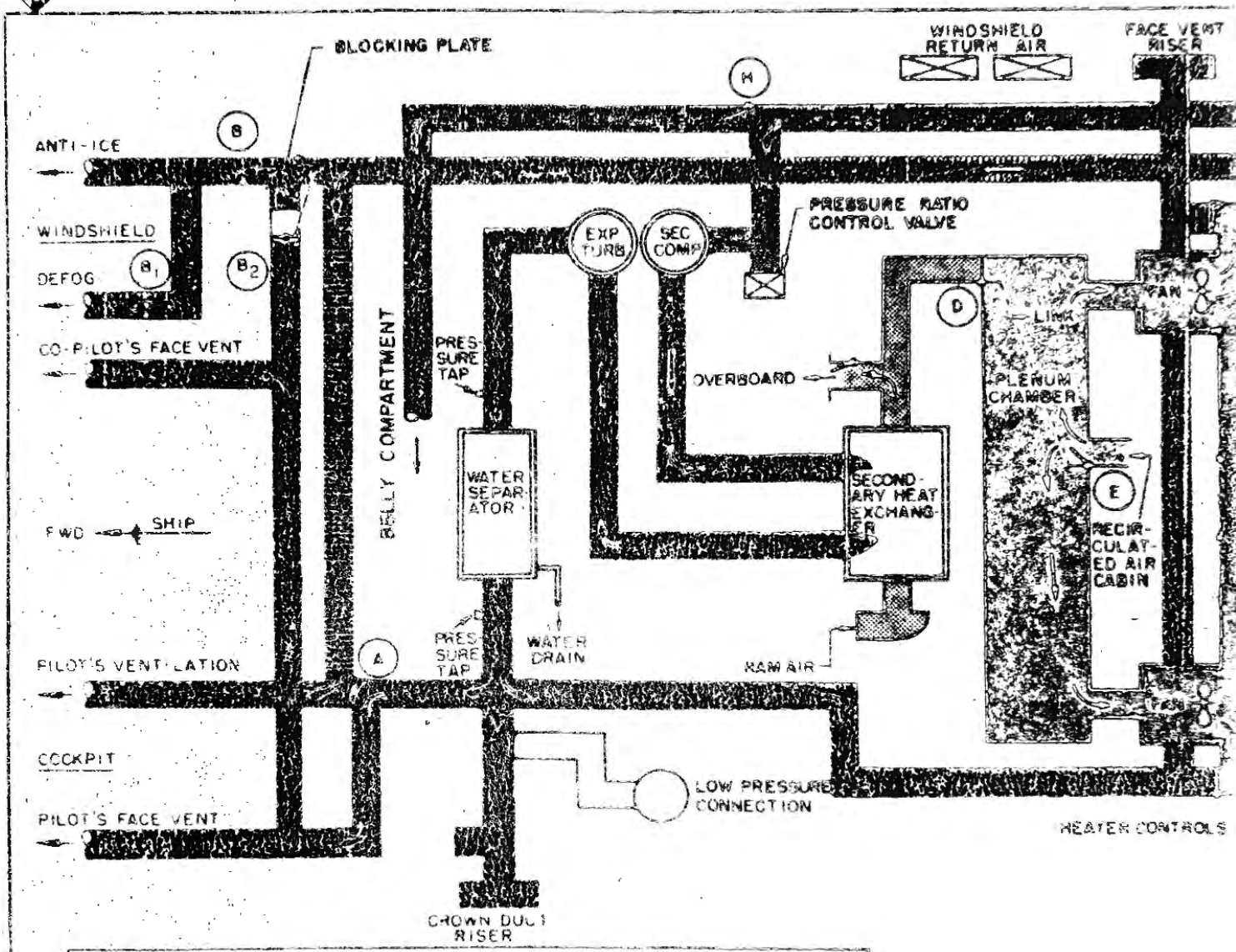
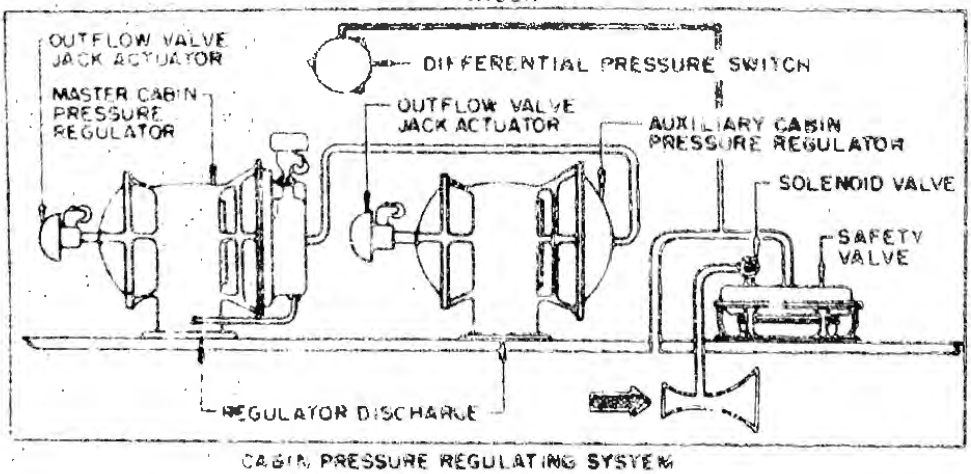
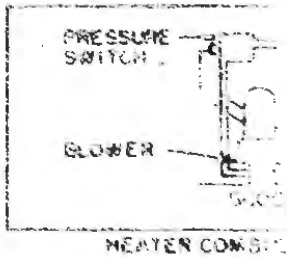


Figure 37. (Sheet 1 of 2 Sheets) Pressurized Flig



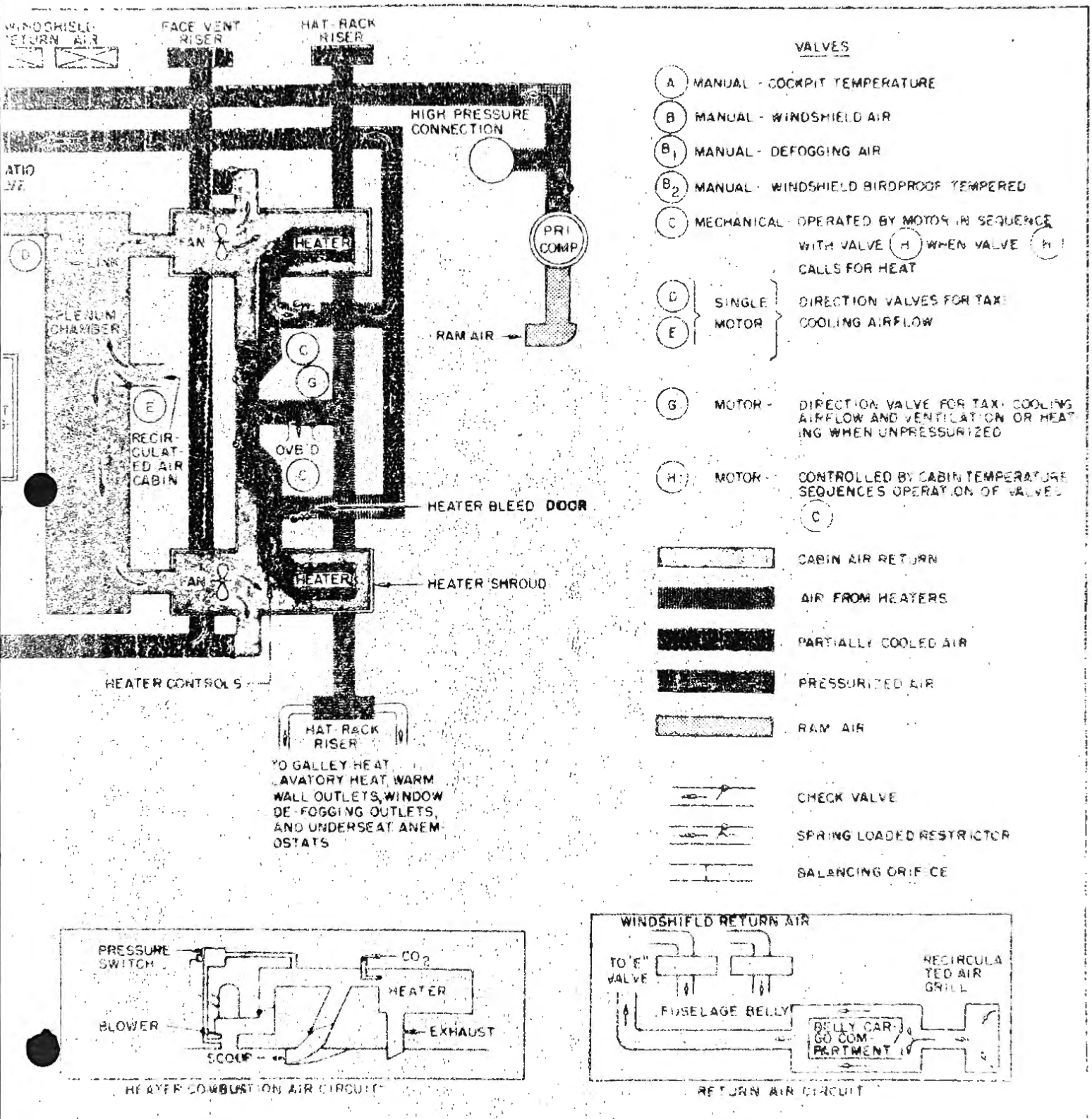


CABIN PRESSURE REGULATING SYSTEM



HEATER CONTROLS

Figure 39. (Sheet 1 of 2 Sheets) Pressurized



Pressurized Pilot's Cabin Heat Air Flow Schematic

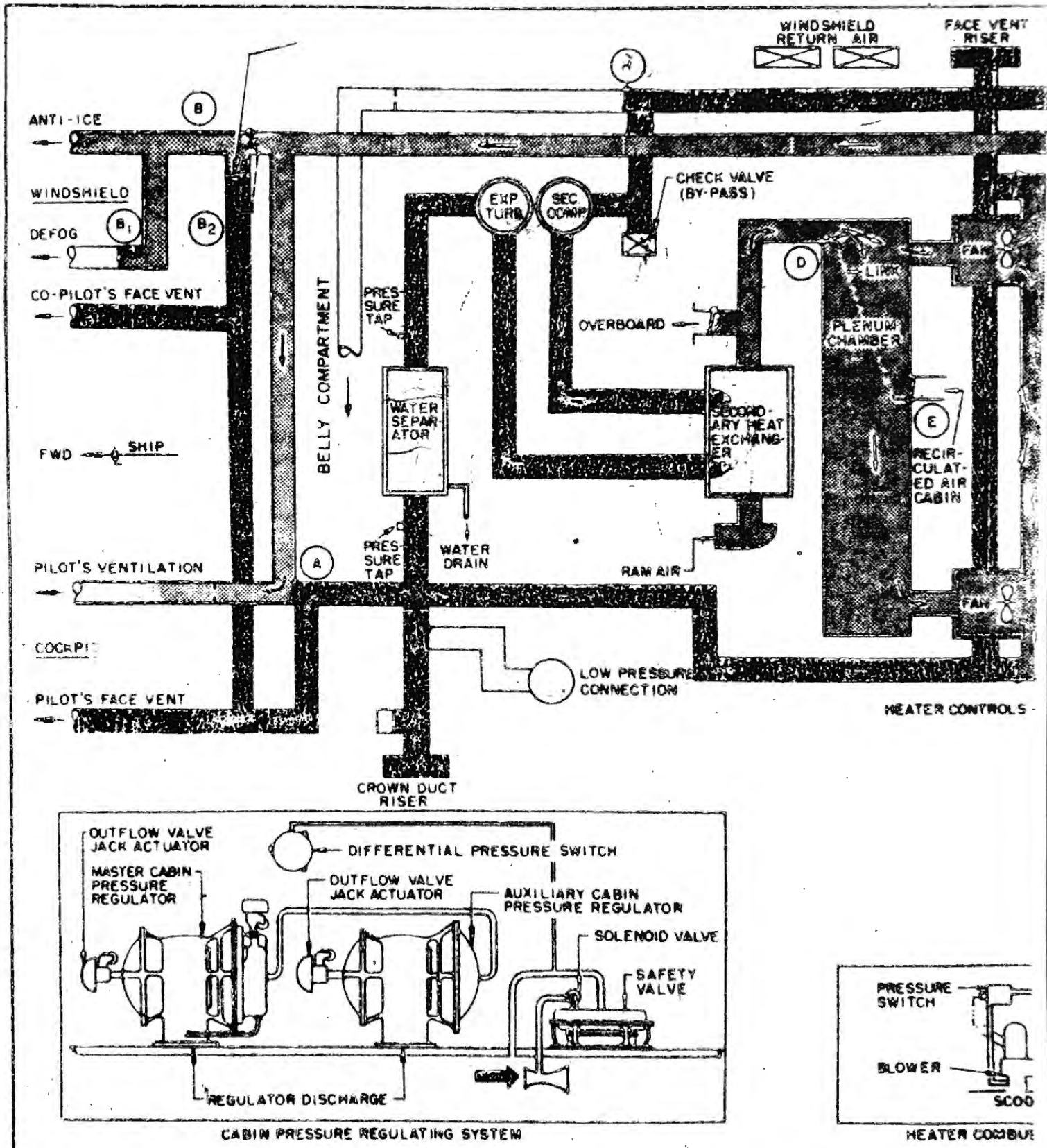
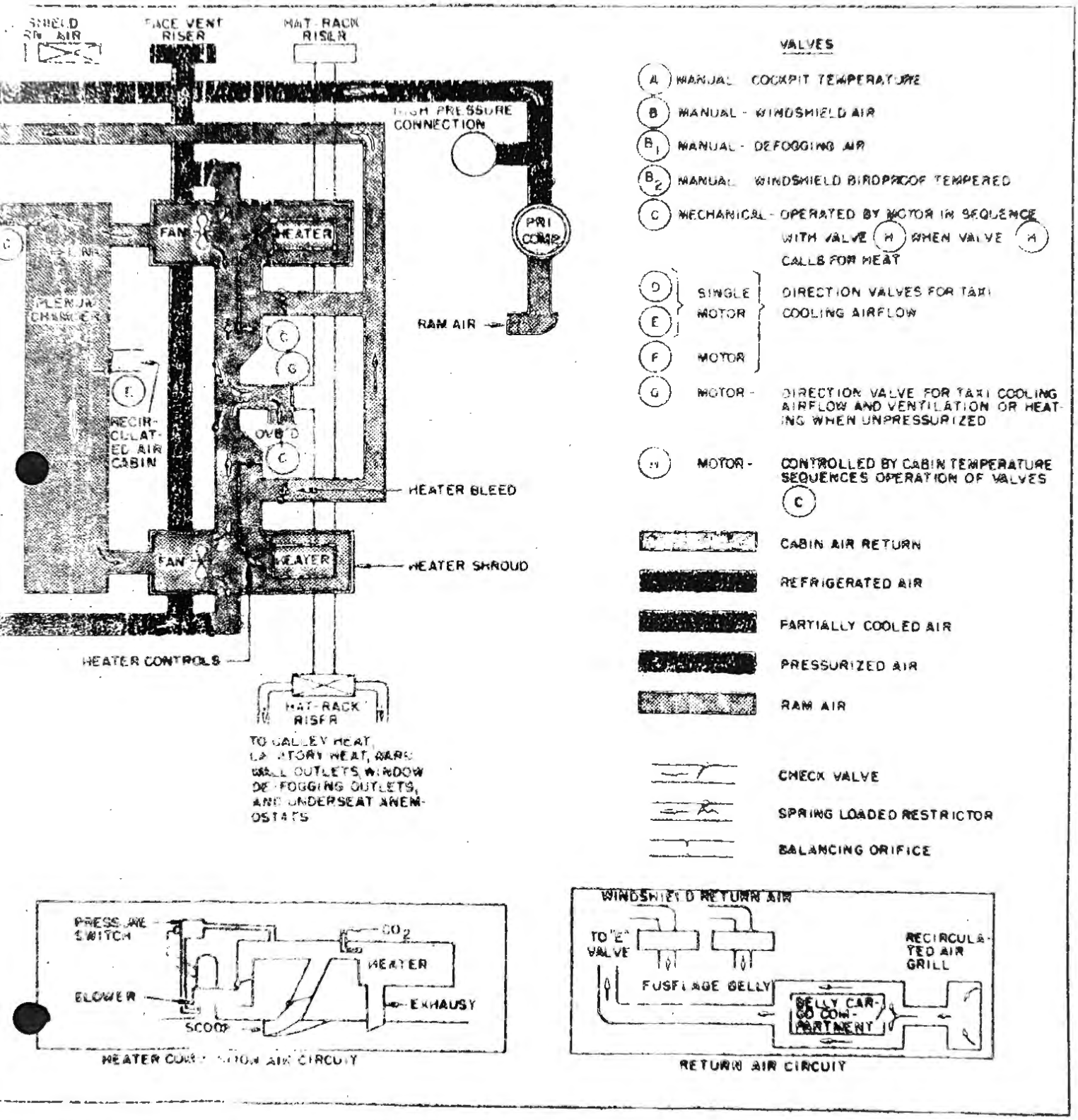


Figure 41. (Sheet 1 of 2 Sheets) Tax



Sheet 1 of 2 Sheets) Taxi Cooling Air Flow Schematic

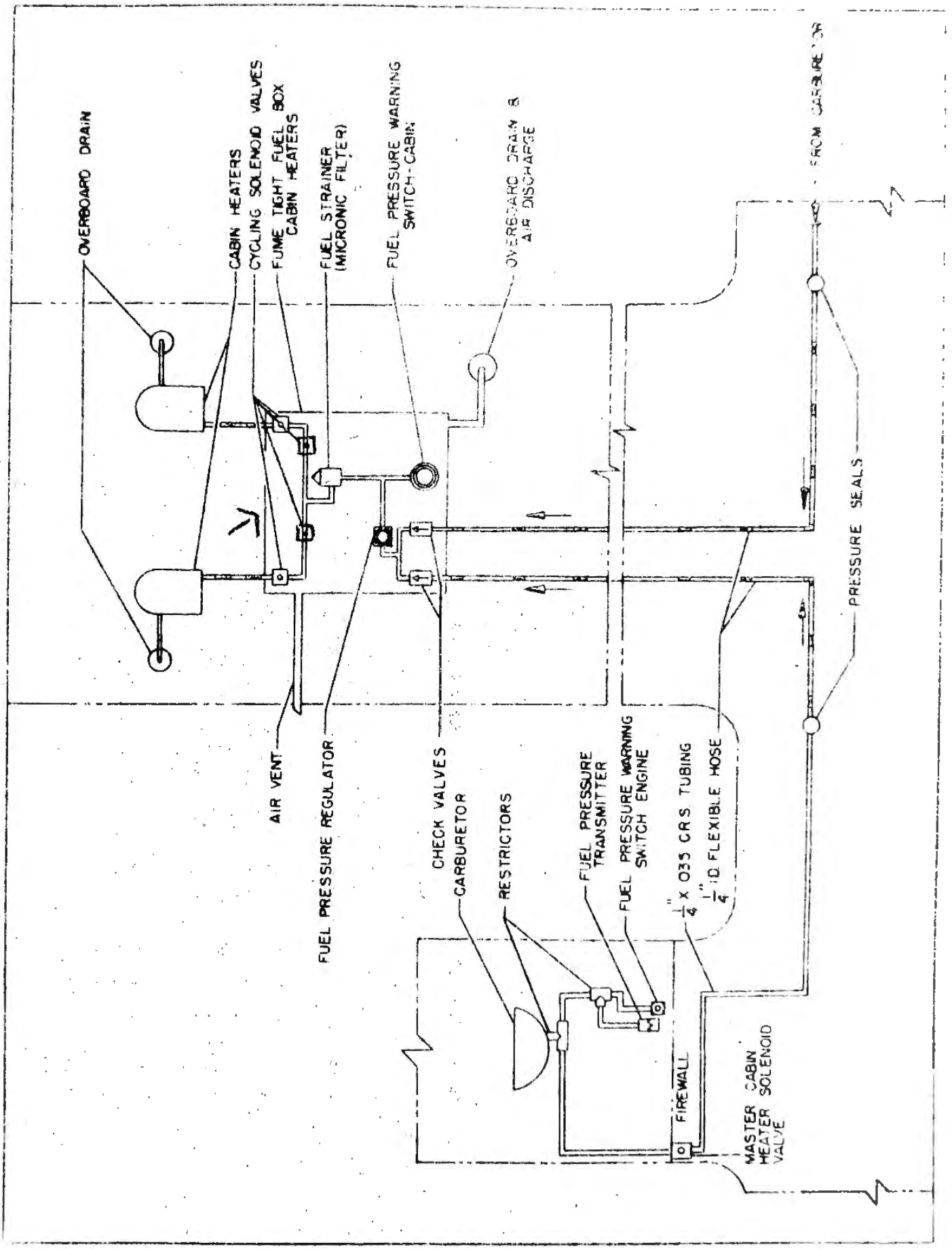
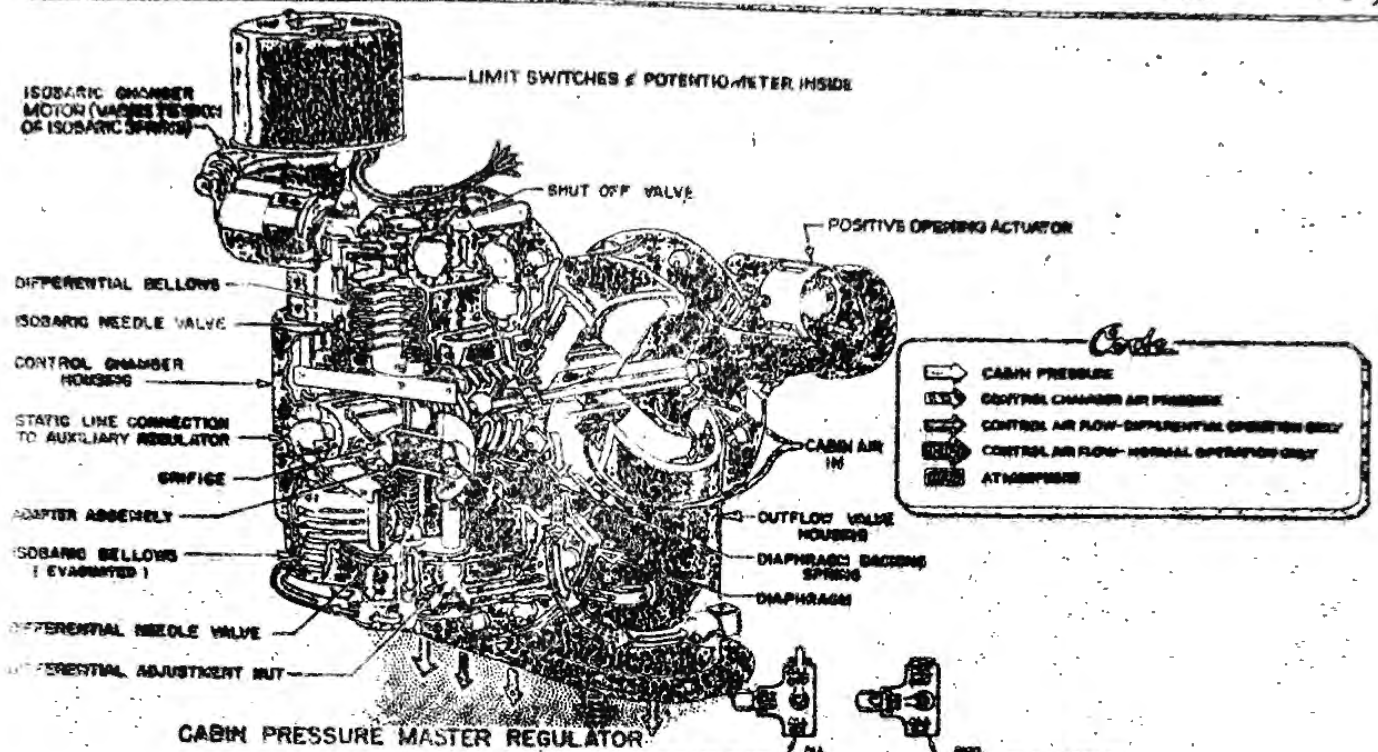
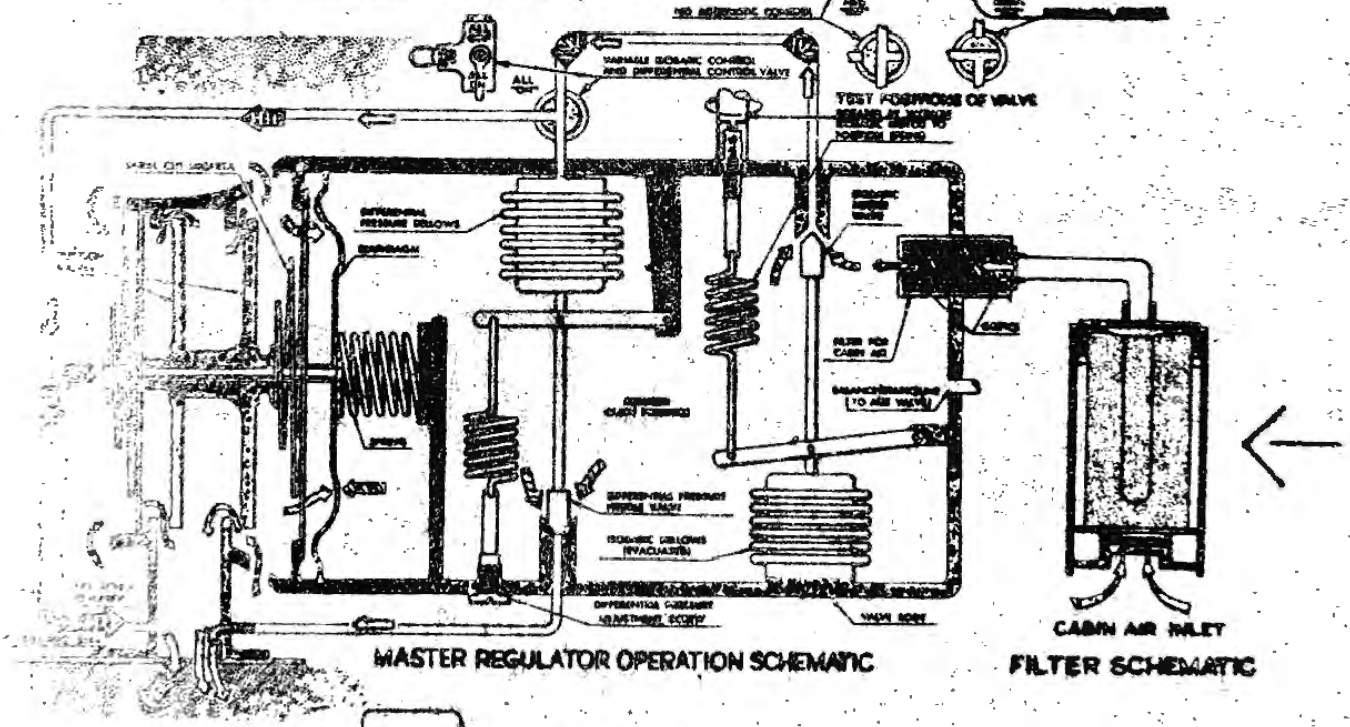


Figure 1-1. Cabin heater fuel system schematic

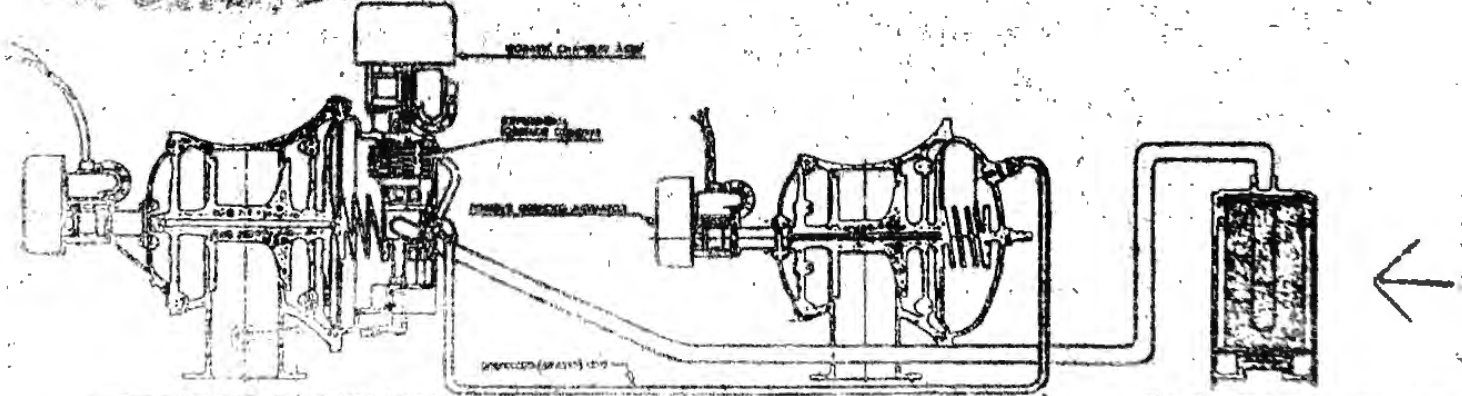


CABIN PRESSURE MASTER REGULATOR



MASTER REGULATOR OPERATION SCHEMATIC

CABIN AIR INLET FILTER SCHEMATIC



MASTER REGULATOR (CROSS SECTION) AUXILIARY REGULATOR (CROSS SECTION) FILTER (CROSS SECTION)

CABIN HEATER FUEL SYSTEM-GENERAL (See figure 51).

A restrictor "TEE" fitting with a #50 drill size hole is used at the engine carburetor to connect the heater fuel supply line. From there, it is routed to a master heater fuel solenoid mounted near the top of the aft side of each firewall and thence to the fuel fume-tight box in the fuselage. This box is located near the cabin heaters and is vented overboard. Fuel entering this box passes a check valve, a fuel pressure regulator valve, a fuel strainer and thence through the cycling solenoid valves to the heaters. A fuel pressure warning unit is also mounted in this box and its "FUEL FAILURE" indicator light is mounted just below the "FUEL SELECTOR" switches on the right hand side of the overhead switch panel.

During ground operation of the heater it is necessary to operate the booster pump on the side from which fuel is selected. A "FUEL SELECTION" switch is located on the right hand side of the overhead switch panel to provide a means of opening the master solenoid on the side selected to supply fuel to the heaters. In flight, fuel preasure is provided by the engine-driven fuel pumps.

Cabin Heater Fuel Fume Tight Box (See figure 75).

The fuel fume-tight box is located midway between the two cabin heaters at fuselage station 350 and is accessible through the aft heater access hatch. This is a stainless steel box with a removable cover. This box contains two check valves, four cycling solenoids, a micronic fuel filter, a fuel regulator valve and a fuel pressure warning unit. All electrical leads are attached to a common plug. The box is vented to atmosphere. A sump arrangment is used to drain the box overboard. The box is attached to structure at an angle to assure complete draining of the box.

A thermoswitch is mounted in the box to give indication of a fire. CO_2 can be discharged into the box by pulling the "SELECTOR-CABIN HEATER FUEL" selector handle and then pulling the "CO_2 DISCHARGE" handle. Refer to Chapter 19 for complete details.

Cabin Heater Check Valves (See figure 75).

Two swing type check valves are mounted in the fuel fume-tight box. These valves are connected into the heater fuel supply line from each engine nacelle. A direction of flow arrow is stamped on each valve and this arrow must point towards the fuel pressure regulator valve.

Cabin Heater Fuel Pressure Regulator Valve (See figure 75).

The fuel pressure regulator valve is located in the cabin heater fuel fume-tight box. The function of this valve is to reduce the fuel pressure coming from the fuel booster pumps to the engine driven fuel pumps. This regulator valve is set to maintain a pressure of 3 psi and a flow rate of 3 to 10 gpn. An arrow is stamped on this regulator valve to indicate direction of flow. This arrow must point downstream and away from the check valve.

Cabin Heater Fuel Filter (See figure 8).

The cabin heater fuel filter is mounted in the fuel fume-tight box and its function is to filter the fuel before it enters the cycling solenoid valves and cabin heaters. This unit uses a disc type filter element which is located within a removable bowl. The filter element may be removed for cleaning by removing the filter bowl. The filter bowl must be torqued to 40-50 inch pounds and lock wired. A direction of flow arrow is stamped on the filter and this arrow must point towards the center of the fume-tight box and the cycling solenoid valves.

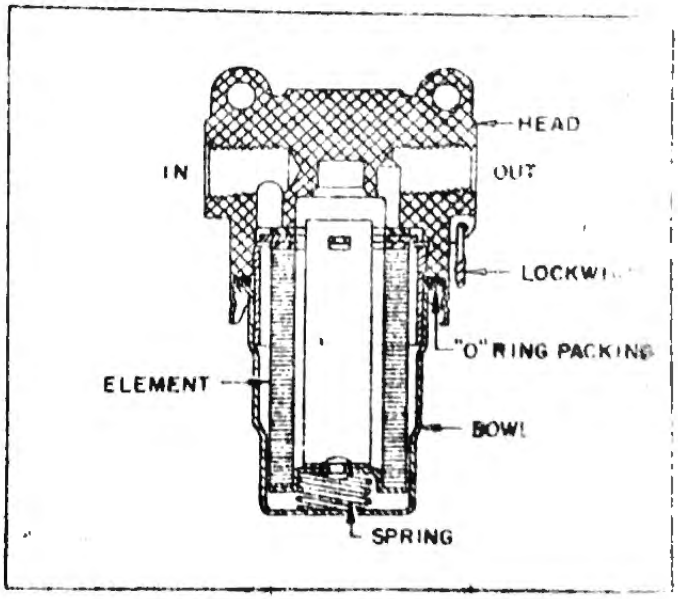


Figure 8. Cabin Heater Fuel Filter

Cabin Heater Master Solenoid Valve
(See Figure 9)

The master solenoid valve is located on the top aft side of each nacelle firewall. Its function is to control the flow of fuel from the main engine fuel pressure line to the cabin heaters' fuel fume-tight box. This is a solenoid operated valve and is either fully closed or fully open. A direction of flow arrow is stamped on the valve and this arrow will point towards the fuselage when the valve is properly installed.

Power is supplied from the 28 volt d-c forward distribution bus through the toggle type "CABIN HEATER FUEL" circuit breaker, located on the main circuit breaker panel, to the "FUEL SELECTOR" switch on the right hand side of the overhead switch panel, which controls the electrical circuit to the right or left master solenoid valve. Actuation of the "SELECTOR CABIN HEATER FUEL" handle, located on the glare shield, will actuate the cabin heater fire cut-off switch, on the bulkhead forward of the instrument panel, and open the electrical circuit to the "FUEL SELECTOR" switch, thereby de-energizing the master solenoid valve.

Cabin Heater Cycling Solenoid Valves
(See Figure 9)

Four cycling solenoid valves are mounted in the cabin heater fuel fume-tight box and these valves are the same type as the master solenoid valves. A direction of flow arrow is stamped on each valve and this arrow must point down stream and away from the fuel filter.

Each heater fuel circuit contains two cycling solenoid valves in series hydraulically and parallel electrically, supplied by 28 volt d.c. power. The cycling solenoids are normally closed.

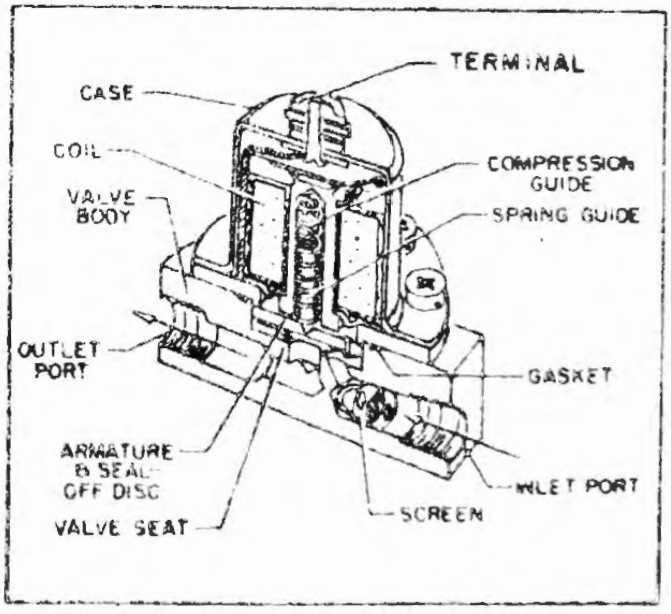
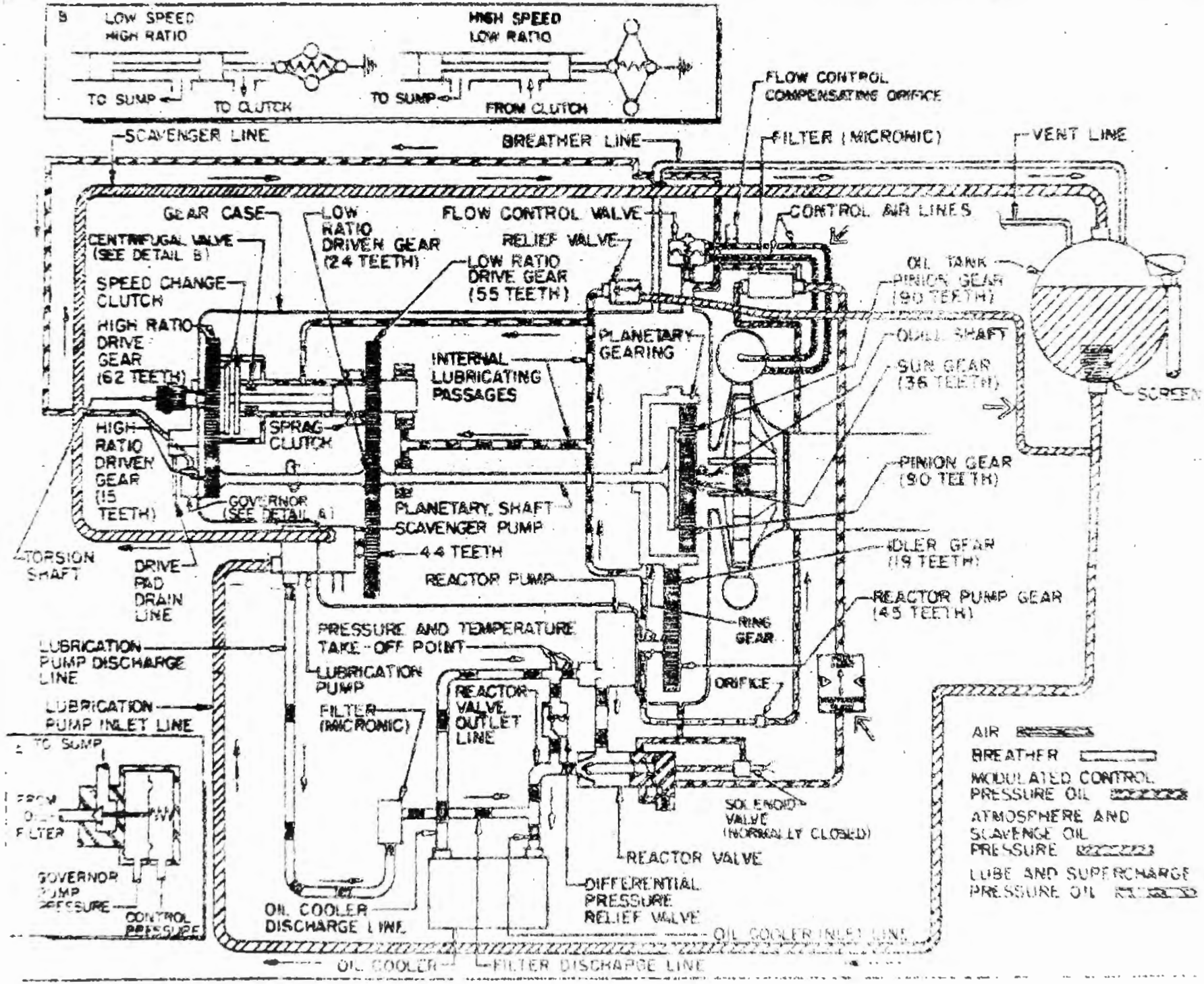


Figure 9. Cabin Heater Fuel System Typical Solenoid Valve.


B
LOW SPEED
HIGH RATIO
HIGH SPEED
LOW RATIO
TO SUMP
TO CLUTCH
TO SUMP
FROM CLUTCH
SCAVENGER LINE
BREATHER LINE
FLOW CONTROL
COMPENSATING ORIFICE
FILTER (MICRONIC)
VENT LINE
GEAR CASE
CENTRIFUGAL VALVE
(SEE DETAIL B)
SPEED CHANGE
CLUTCH
HIGH RATIO
DRIVE
GEAR
(62 TEETH)
LOW
RATIO
DRIVEN GEAR
(24 TEETH)
FLOW CONTROL VALVE
RELIEF VALVE
LOW RATIO
DRIVE GEAR
(55 TEETH)
CONTROL AIR LINES
OIL TANK
PINION GEAR
(90 TEETH)
PLANETARY
GEARING
INTERNAL
LUBRICATING
PASSAGES
DUAL SHAFT
SUN GEAR
(36 TEETH)
SCREEN
HIGH
RATIO
DRIVEN
GEAR
(15
TEETH)
SPRAG
CLUTCH
GOVERNOR
(SEE DETAIL A)
PLANETARY SHAFT
SCAVENGER PUMP
44 TEETH
PINION GEAR
(90 TEETH)
IDLER GEAR
(19 TEETH)
TORSION
SHAFT
DRIVE
PAD
DRAIN
LINE
REACTOR PUMP
REACTOR PUMP GEAR
(45 TEETH)
RING
GEAR
PRESSURE AND TEMPERATURE
TAKE-OFF POINT
LUBRICATION
PUMP DISCHARGE
LINE
LUBRICATION
PUMP
ORIFICE
LUBRICATION
PUMP INLET LINE
FILTER
(MICRONIC)
REACTOR
VALVE
OUTLET
LINE
TO SUMP
FROM
OIL
FILTER
SOLENOID
VALVE
(NORMALLY CLOSED)
REACTOR VALVE
GOVERNOR
PUMP
PRESSURE
CONTROL
PRESSURE
DIFFERENTIAL
PRESSURE
RELIEF VALVE
OIL COOLER
DISCHARGE LINE
OIL COOLER INLET LINE
OIL COOLER
FILTER DISCHARGE LINE
AIR
BREATHER
MODULATED CONTROL
PRESSURE OIL
ATMOSPHERE AND
SCAVENGE OIL
PRESSURE
LUBE AND SUPERCHARGE
PRESSURE OIL

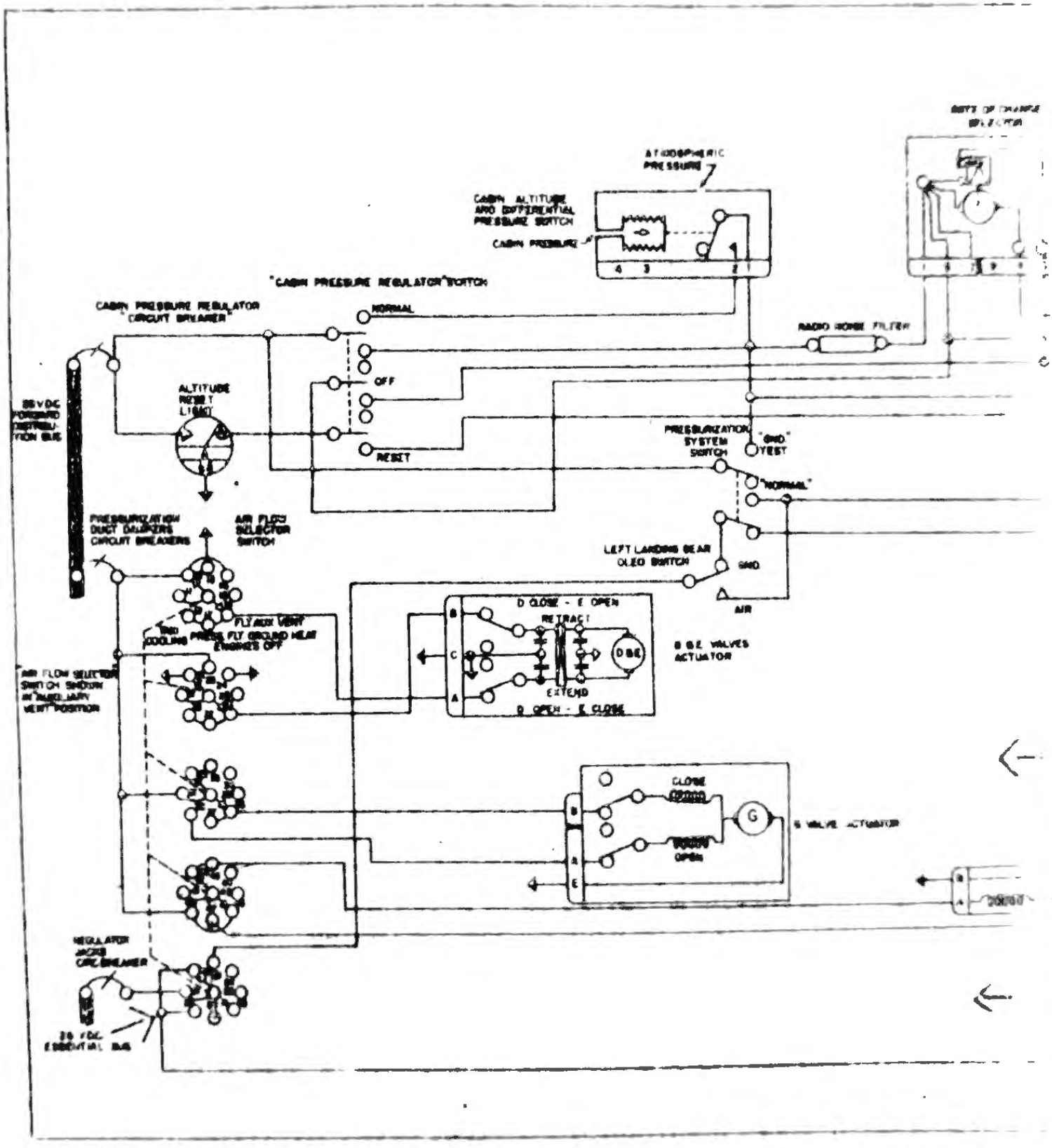
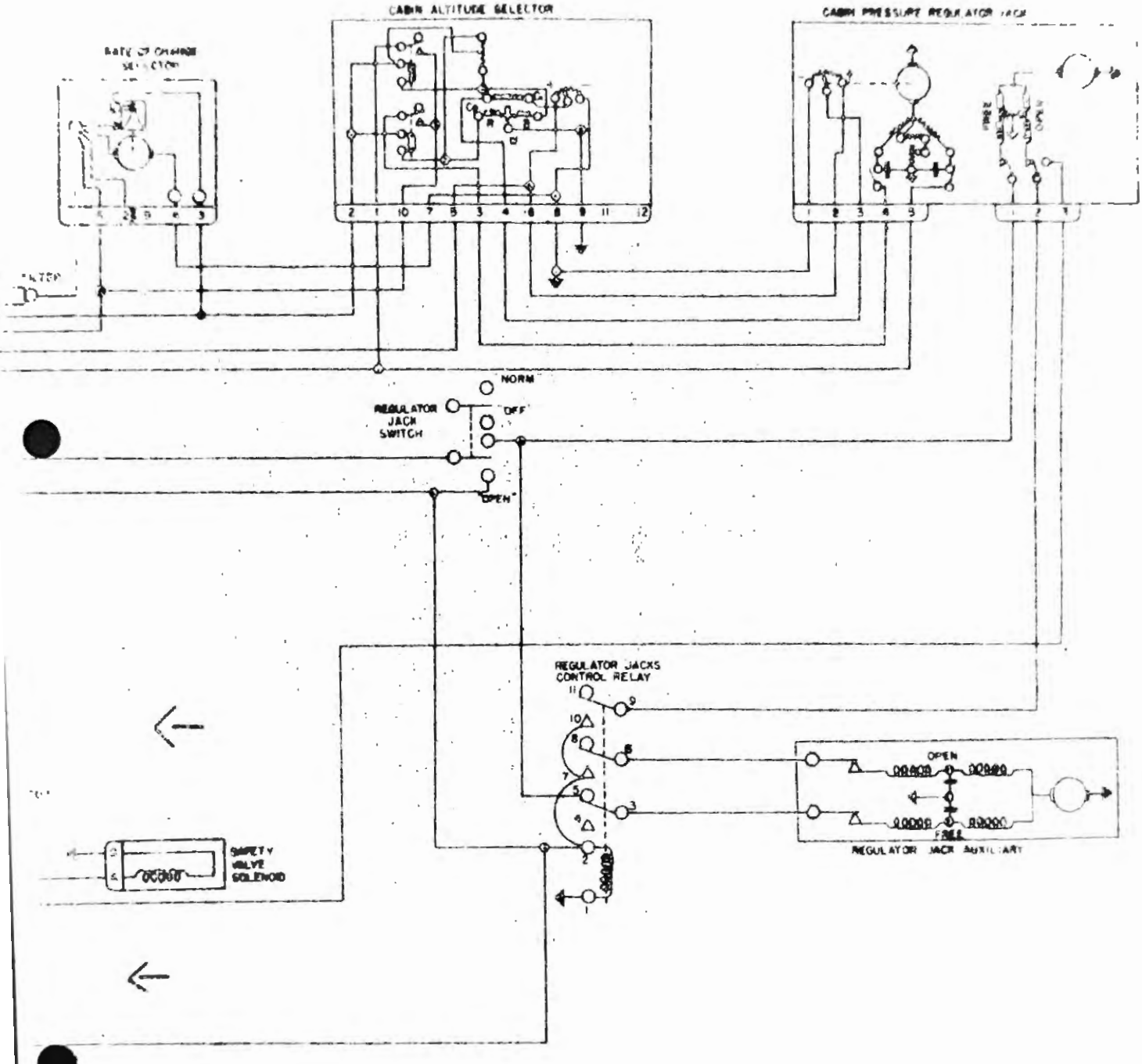


FIGURE 73 (SHEET 1 OF 3 SHEETS) PRESSURIZATION



PRESSURIZATION CONTROL CIRCUIT SCHEMATIC

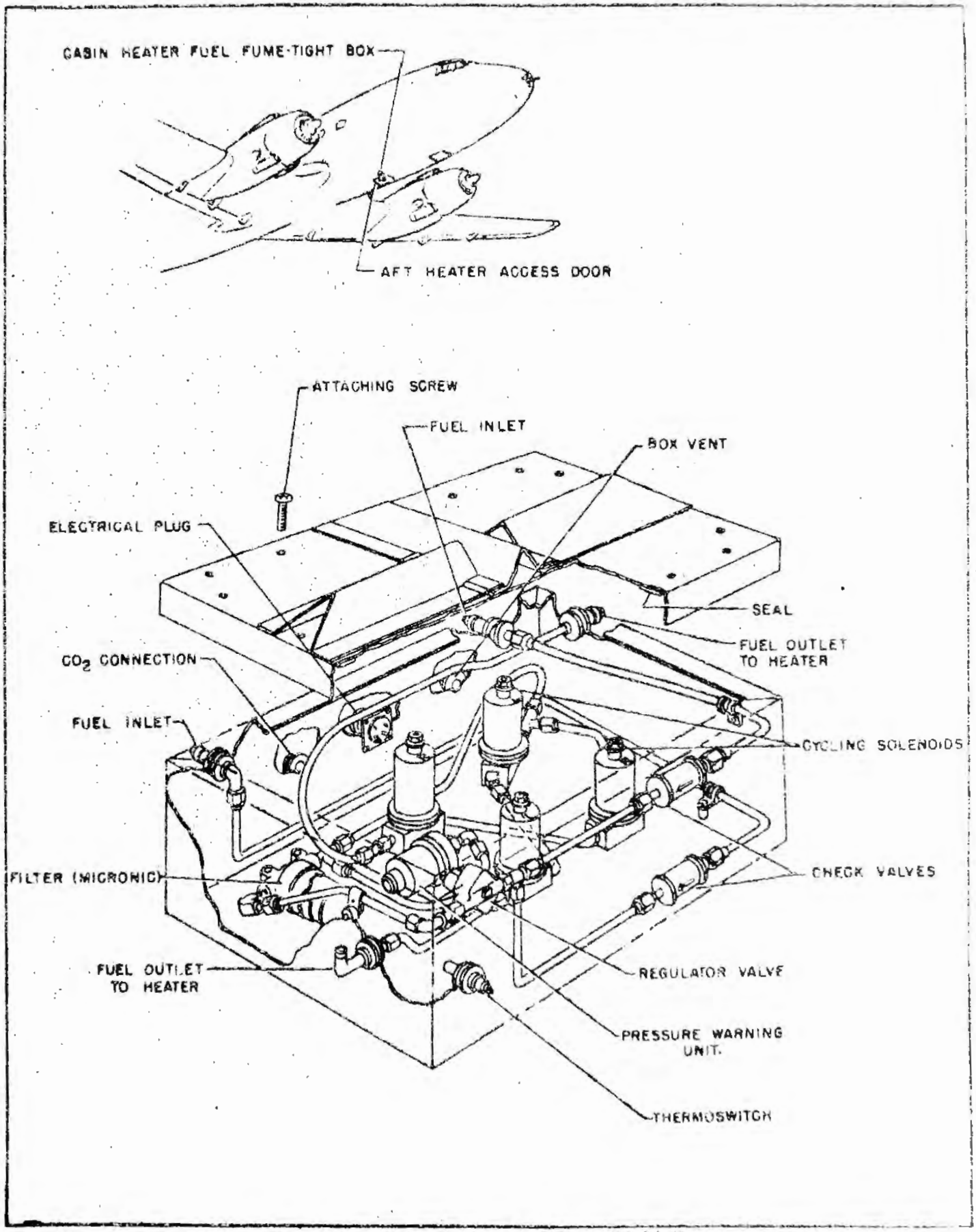


Figure 75. Cabin Heater Fuel Fume-Tight Box

Primary Compressor

Two speed, single-stage with 6.5 inch centrifugal impeller and automatic clutch.

Lubrication — Pressure and splash system.

Type of Oil — Aeroshell 1AC

Input Speed RPM

	Increasing Speed	Decreasing Speed
Low Ratio	1890-3920	3920-1400
High Ratio	0-1890	1400-0

Performance Limits

Maximum input shaft speed for five minutes.	4060 RPM
Maximum input shaft overspeed for one minute.	4340 RPM
Maximum impeller speed.	40,000 RPM
Maximum inlet air temperature.	140°F
Maximum operating altitude	20,000 feet
Maximum ambient temperature	200°F
Minimum starting temperature	-30°F
Maximum oil temperature	225°F
Minimum oil temperature for continuous operation	50°F
Maximum pressure differential of compressor inlet pressure below atmospheric pressure.	1 inch Hg.

Primary Compressor Oil Pressure

Normal	80 PSI
Minimum	60 PSI
Maximum	110 PSI
Adjustment Check	80-90 PSI at 1000 engine RPM and 50°C oil temperature.

Primary Compressor Warning Unit

Operates at 42 ± 4 PSI

Primary Compressor Oil Tank

Service oil tank to "FULL" mark on dip-stick. Use Aeroshell 1 AC

Capacity — 1.75 gallons plus 1.25 gallon expansion space.

Primary Compressor Oil Cooler and Regulator Valve

Thermostatic valve closes	125°F ± 3°F
Pressure relief valve opens	40 ± 5 PSI
Oil cooler	9 inch mechanical type

Primary Compressor Oil Filter

Bypass relief valve opens	45 PSI
Element	AN6236-2

Torque bolt which secures the lower half of the filter body to the upper half, 250 in. lbs.

Primary Compressor Oil Consumption

The oil level of the compressor shall be checked at each fuel servicing. Any time it is necessary to add two (2) pints of oil or more, the unit must be run and the system checked for leaks.

Primary Compressor Oil Leakage

Oil leaks which produce stains or wet spots only, need not be corrected. Any tendency to puddle, form drops or any dripping is not satisfactory and must be corrected.

Cabin Supercharger Repair Limitations

It is not permissible to change the following sub-assemblies:

Flow Control Valve
Governor
Reactor Limiter Valve

These three units may be set only in the test cell. Wrong adjustment can result in impeller overspeed and possible failure. When replacing the reactor valve, the original limiter valve shall be reinstalled.

Cabin Air Cooling Turbine

Service refrigerator unit sump tank to mark on filler cap dipstick.

Oil capacity	Approximately 500 cubic centimeters.
Type of oil	Aeroshell 1AC
Maximum compressor inlet temperature	230°F

Water Separator

Moisture condenser	Fiberglass bag
Moisture eliminator	Tubing baffles
By-pass valve	Starts to open when pressure drop across unit exceeds 3 inches Hg.

Secondary Heat Exchanger

Maximum temperatures -65°and ± 400°F

Master Pressure Regulator

Isobaric operation	Regulates cabin pressure within a 0.20 PSI variation.
Differential operation	Maintains cabin pressure at 3 PSI above atmospheric. Operational check specifications 6.2" ± 0.1" Hg.

Auxiliary Pressure Regulator

Operates in unison with the master regulator.

Cabin Air Safety Valve

Set to relieve at 3.25 psi positive pressure; operational check specifications 6.5" ± 0.1 Hg. Set to relieve at 0.15 psi negative pressure.

Differential Pressure Switch

Open when pressure between cabin and atmosphere is less than 4.5 inches of water (approximately).

Pressure Ratio Control Valve

Valve opens when pressure ratio across primary compressor tends to exceed 1.9 to 1.

After Cooler

Single pass cooler
Used only during ground cooling.

Cabin Heater

Capacity	100,000 BTU per hour
Fuel	100/130 octane

Cabin Leakage

Maximum cabin leakage with cabin compressor stopped at a cabin differential pressure of 5" Hg. (2.46 psi) is 2000 ft./min. as indicated by the cabin rate of climb indicator (all normal vents open).

Ground Air Conditioner Use

In order to use the ground air conditioner most efficiently, it is necessary only to connect the hose at the ground fitting in the refrigerator compartment; also, keep the cabin entrance doors closed.

Recirculation Air Blower.

Air Flow	1350 cfm at 6.5 inches water at 8000 feet altitude
Rated	3.2 horsepower at 7000 rpm and 27 volts.

Combustion Air Blower.

Air Flow	50 cfm at 8.4 inches water at zero altitude
Rated	.34 horsepower at 11,000 rpm

Cabin Heater Combustion Air Ram Pressure Switch.

Opens at	3.9 inches of water
Closes at	5.5 inches of water

Recirculating Air Blower Differential Pressure Switch.

Opens at	1.9 inches of water
Closes at	3.0 inches of water

Cabin Heater Cycling Switches.
Normally closed switch. Non-adjustable type opens at 260 ± 8°F

Cabin Heater Overheat Switches.
Normally open switch. Non-adjustable type closes at 350 ± 8°F

Cabin Heater Master Solenoid Valve.
Normally closed, opens when energized.

Cabin Heater Cycling Solenoid Valve.
Normally closed, opens when energized.

Cabin Heater Fuel Check Valve.
Normally closed swing check valve
Opens at 0.5 psi.

Cabin Heater Fuel Pressure Regulator Valve.
Pressure setting 12 ± 1/4 psi
Flow rate 3/10 gallons per hour

Cabin Heater Fuel Filter.
Torque filter bowl to 40-50 inch pounds

Cabin Heater Fuel Pressure Warning Unit.
Closes when fuel pressure drops to 9 psi.

Conversion Chart.

The following conversion chart may be used to convert inches of mercury into pounds per square inch of pressure.

Inches of Mercury (Hg.)	Pounds Per Square Inch (Psi)
1.	.49
1.5	.74
2.	.98
2.5	1.23
3.	1.47
3.5	1.72
4.	1.97
4.5	2.21
5.	2.46
5.5	2.70
5.6	2.749
5.7	2.798
5.8	2.847
5.9	2.896
6.	2.95
6.1	2.995
6.2	3.04
6.3	3.09
6.4	3.14
6.5	3.19

Re-Engagement Of Primary Compressor Disconnect Controls (See Figure 79).

1. With power on the airplane, determine that "PRIMARY COMPRESSOR DISCONNECT" switch is in the "AUTO" position.

2. Remove the inboard side piece of accessory section cowling on right hand engine.

3. Pull up on the reconnect knob until it locks in place.

4. Remove safety wire from reconnect feeler then depress feeler.

WARNING

Determine that "IGNITION" switches are in the "OFF" position.

5. If reconnect feeler can be only partially pushed in, rock the engine propeller until the splines are fully engaged.

CAUTION

When installing a primary compressor on the engine DO NOT install it with the compressor input drive shaft in the disconnected position. Be sure that the shaft is in the EXTENDED position and that the manual reconnect knob (See 17-6, page 1, Figure 79) is pulled all the way out and locked in this position. If installation is not accomplished in this manner, the 3/16" shaft return spring rod will extend beyond the splined drive and may become bent during installation.

When installing, reconnecting or working on a primary compressor, DO NOT turn over the crankshaft with the propeller or starter while holding the reconnect feeler in the depressed position. If the splined drive is not fully engaged with the splined drive of the engine, the point-end of the reconnect feeler will engage between the splines of the compressor input drive shaft. Being constructed of aluminum, it can easily become damaged and result in a false indication.

6. Replace safety wire in reconnect feeler.

Special Instructions.

1. Located on co-pilot's console panel.

3. Reconnect knob is located on top of the compressor. The shaft return spring will then tend to re-engage the torsion shaft to the engine drive.

4. The feeler is mounted on the unit near the disconnect knob. If the drive spline is fully engaged, the reconnect feeler will bottom against its shoulder.

5. The shaft return spring is strong enough that the shaft may be heard going into place.

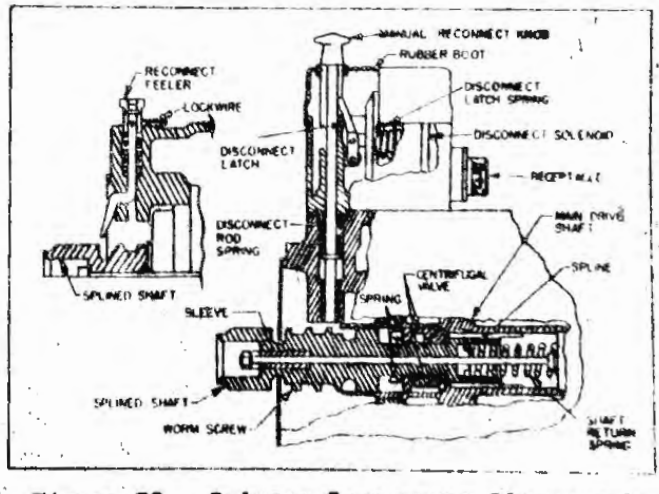


Figure 79. Primary Compressor Disconnect Unit.

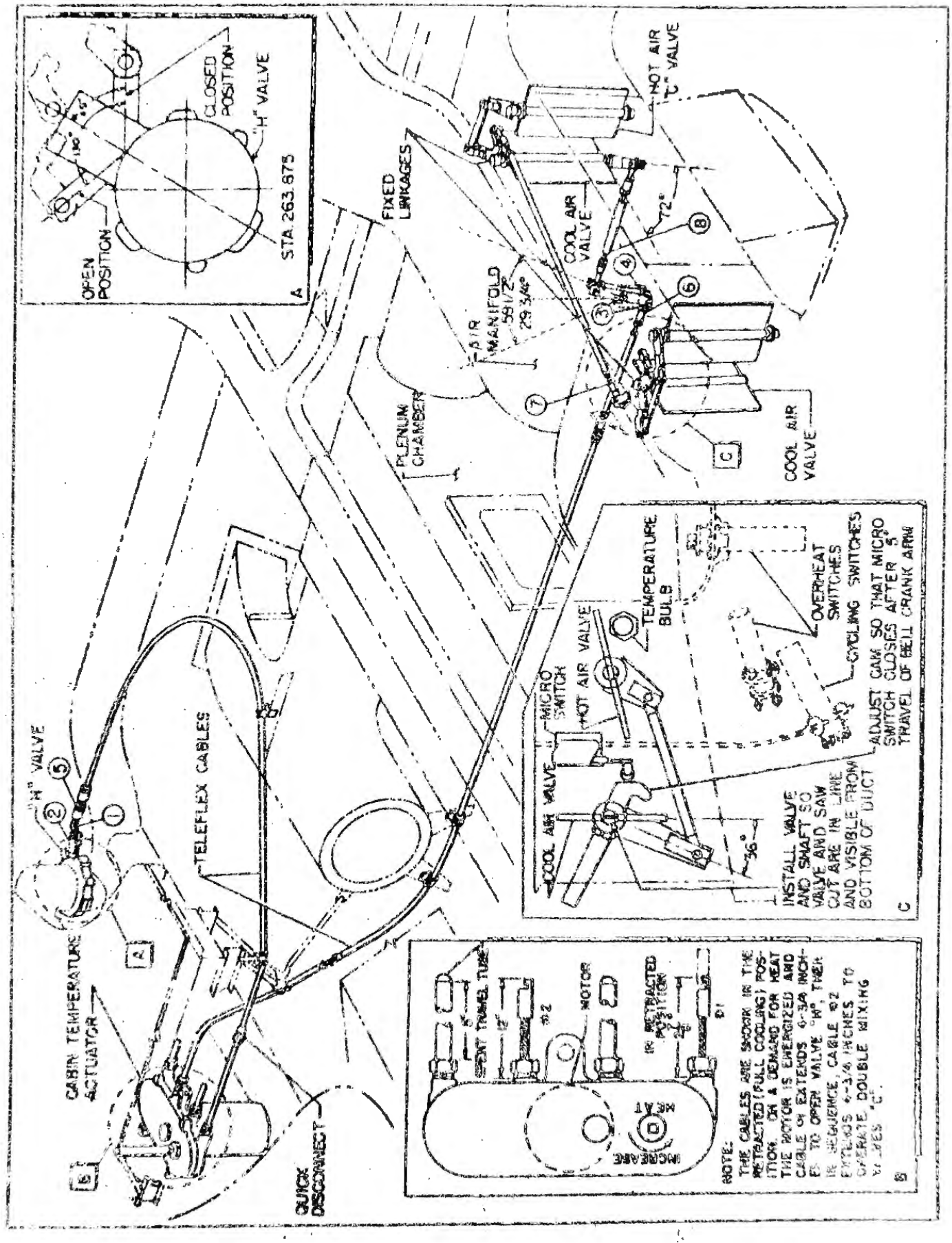

"H" VALVE
CLOSED POSITION
OPEN POSITION
STA. 263.875
A
FIXED LINKAGES
HOT AIR "C" VALVE
COOL AIR VALVE
AIR MANIFOLD
PLENUM CHAMBER
TELEFLEX CABLES
CABIN TEMPERATURE ACTUATOR
QUICK DISCONNECT
B
MOTOR
INCREASE
IN RETRACTED POSITION
NOTE:
THE CABLES ARE SHOWN IN THE RETRACTED (FULL COOLING) POSITION. ON A DEMAND FOR HEAT THE MOTOR IS ENERGIZED AND CABLE #1 EXTENDS 6-3/4 INCHES TO OPEN VALVE "H", THEREBY RETRACTING CABLE #2 APPROXIMATELY 6-3/4 INCHES TO OPERATE DOUBLE MIXING VALVES "C".
C
COOL AIR VALVE
MICRO SWITCH
HOT AIR VALVE
TEMPERATURE BULB
OVERHEAT SWITCHES
CYCLING SWITCHES
ADJUST CAM SO THAT MICRO SWITCH CLOSES AFTER 5° TRAVEL OF BELL CRANK ARM
INSTALL VALVE AND SHAFT SO VALVE AND SAW CUT ARE IN LINE AND VISIBLE FROM BOTTOM OF DUCT
36°
72°

Figure 83. Rigging Of "H" And "C" Valves

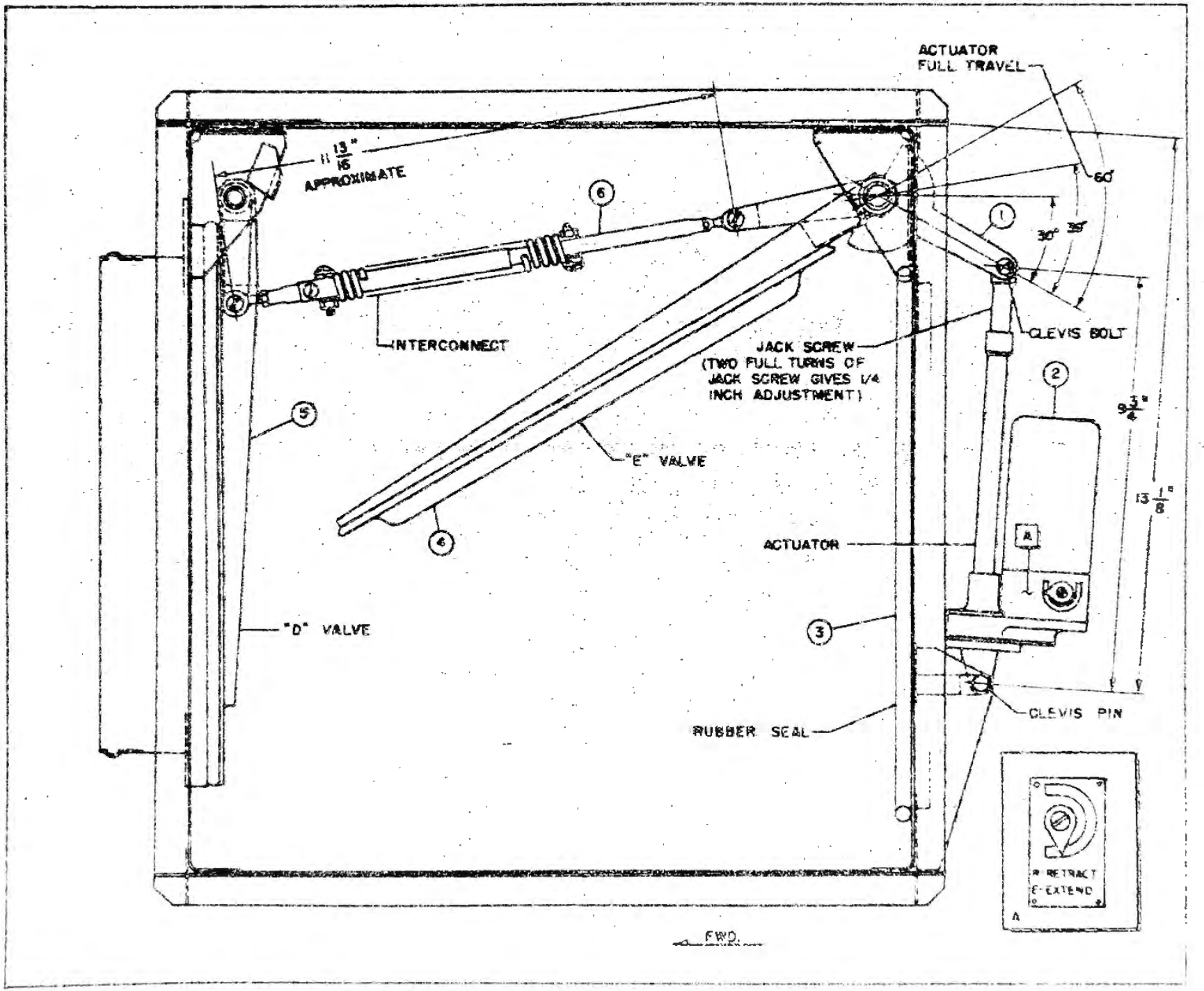


Figure 86. Rigging Of "D" And "E" Valves

"D" AND "E" VALVES AND ACTUATOR (See figure 26.)

The "D" and "E" valves are located in the plenum chamber and are mechanically connected so that when one valve is in the closed position the other valve will be in the open position and vice versa. "D" valve is installed on the forward right hand side and is a round flapper type valve. "E" valve is installed on the aft side, in the center of the plenum chamber and is a square flapper type valve. An actuator is installed on the aft right side of the plenum chamber and is mechanically connected to "E" valve. The actuator of "E" valve is controlled by the "AIR FLOW SELECTOR" switch. Power for the circuit is supplied from 28 volt d-c forward distribution bus through the "PRESS. DUCT DAMPERS" circuit breaker.

When the "AIR FLOW SELECTOR" switch is placed in the "TAXI COOLING" position, the actuator will be energized causing "E" valve to close and "D" valve to open. This allowsanthe ventilation blowers to pull air across the secondary heat exchanger for cooling and to discharge it overboard through the lower manifold assembly duct.

When the "AIR FLOW SELECTOR" switch is placed in the "PRESS. FLT." position, the actuator will be energized causing "E" valve to open and "D" valve to close. This allows the ventilation fans to pull air from the belly compartment and recirculate it through the airplane.

When the "AIR FLOW SELECTOR" switch is placed in the "FLT. AUX. VENT." position, the actuator will be energized causing the "E" valve to close and "D" valve to open. This allows ventilating air to enter the airplane through the secondary heat exchanger air scoop, and to be discharged through the cabin air safety valves and pressure regulators.

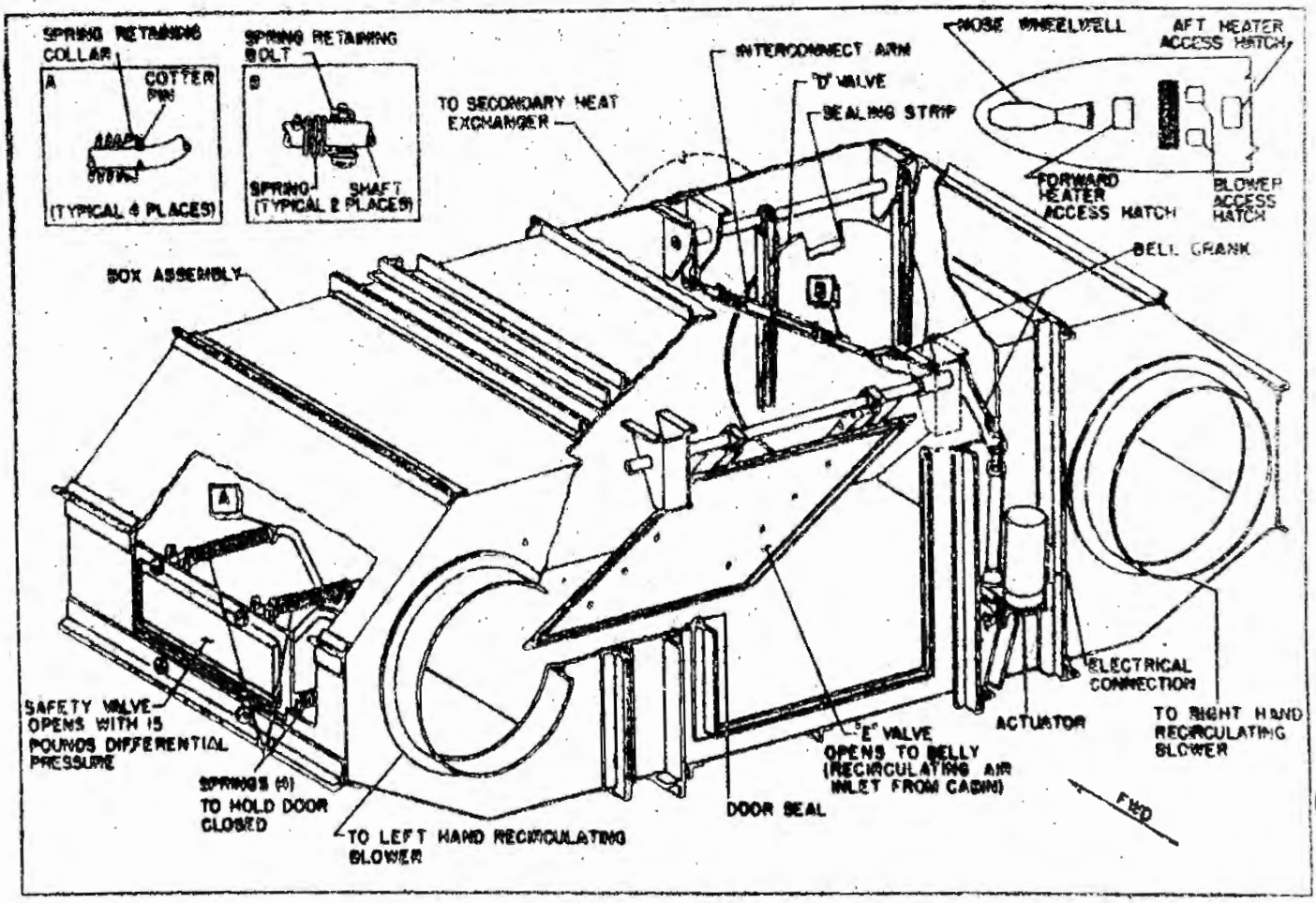


Figure 26. Plenum Chamber And "D" And "E" Valves

ANTI-ICING AND DE-ICING - GENERAL.

Thermal anti-icing is used on this airplane to prevent ice formation on the leading edges of the wings and empennage, on the pitot tubes of the air speed indicating system, and on the ram air scoop of the heating and ventilating system. Thermal anti-icing is also used on the pilots' compartment windshield to prevent ice formation and for defogging. Fluid de-icing is used to prevent and remove ice formation in the carburetor air induction system of both engines and on the blades of both propellers.

An ice indicator mast is located on the left side of the fuselage exterior at the aft end of the pilot's sliding window panel.

A "LEADING EDGE DUCT" temperature gage is located on the extreme right side of the instrument panel. This gage indicates the temperature in the wing leading edges and the fin leading edge. Effective on plane number 413 and up.

WING AND EMPENNAGE ANTI-ICING GENERAL.

The wings and empennage use a thermal anti-icing system to prevent ice formation on their leading edges. Heat for the thermal anti-icing system is produced by four combustion type heaters, two in each nacelle, and is ducted to the wing and empennage leading edges through insulated ducts. The leading edges of the wings and empennage act as ducts for the anti-icing system and are so constructed and insulated that the heated air which passes through them heats the outside skin for a distance of 10 per cent of the chord.

WING AND EMPENNAGE ANTI-ICING SYSTEM OPERATION. (See figure 21).

The anti-icing system is designed so that it will not operate unless there is sufficient ram air entering the ram air scoops located in the leading edges of the wings. The anti-icing system is put into operation by moving the "ANTI-ICING HEATER" switches to the "ON" position. These switches are mounted on the anti-icing control panel which is located on the right side of the pilots' compartment above the co-pilots' console. With the "ANTI-ICING HEATER" switches "ON" and sufficient ram air pressure, the anti-icing system will be automatic in operation and distribution of heated air.

Ram air enters the scoops in the leading edges of the wings and is ducted past dampers, which are opened when the control switches are turned "ON", into the anti-icing heaters. The heated air from both of the anti-icing heaters in each nacelle is manifolded and ducted to a mixing box located in the bottom of the fuselage just forward of the rear spar. From the mixing box the heated air is then routed through ducts to both wing leading edges and to the empennage leading edges. The leading edges of the wings and empennage are heated as the heated air passes through them, preventing the formation of ice. The heated air is then exhausted overboard through openings in the aft ends of the wing, horizontal stabilizer, and fin tips.

Ram Air Intake Scoops And Ducts (See figure 19).

A ram air scoop at station 89 in each center wing supplies ram air to its respective inboard anti-icing heater, and a ram air scoop at station 211 in each outer wing supplies ram air to its respective outboard anti-icing heater.

Ram air entering the ram air scoops flows through the ram air ducts in the nacelles to the anti-icing heaters. Each inboard and outboard ram air duct is equipped with an electrically operated damper motor and damper assembly which controls the introduction of ram air to the anti-icing heater. A welded take-off tube is attached to each of the ram air ducts just forward of the damper assembly. This take-off tube supplies combustion air to the combustion chamber of the anti-icing heater. Attached to the aft end of each ram air duct is a transition duct which connects the ram air duct to the forward end of the anti-icing heater.

Ram Air Damper And Damper Motor (See figure 19).

Each inboard and outboard ram air duct is equipped with a damper and damper motor to control the flow of ram air to the anti-icing heater. The damper, which is a welded plate and shaft assembly, is located within the ram air duct and is in either a fully open or fully closed position. This damper is controlled by the operation of the damper motor mounted externally on the bottom of the ram air duct just forward of the front spar in the nacelle wheel well. The shaft of the damper is connected to the drive shaft of the damper motor by means of a broached sleeve. The damper motor is a reversible 26 volt d-c motor having an operating range of 90 degrees, which either fully opens or fully closes the damper. The damper motor is energized when the anti-icing heater control switch is turned "ON". The damper motor has a built-in switch which energizes the heater circuit only when the damper reaches its fully open position. The damper motor is of the permanent magnet type, has dynamic braking, and is of light weight construction.

Anti-Icing System Mixing Box (See figure 17).

The anti-icing system mixing box, located in the bottom of the fuselage forward of the rear spar, is used to collect and distribute the heated air generated by the anti-icing heaters. The anti-icing mixing box is constructed of aluminum alloy sheet and has an interior baffle used to direct the flow of heated air to the wing and empennage anti-icing system ducts. The mixing box is covered with fiberglas insulation and is sealed at joints to prevent dissipation of heat.

PITOT TUBE ANTI-ICING - GENERAL.

Both pitot tubes in the air speed indicating system are anti-iced by means of built-in electrical heating elements. Separate electrical circuits are provided for each pitot tube heating element, but both circuits are controlled through a single on-off control switch located on the left side of the overhead switch panel in the pilots' compartment. Two amber press-to-test indicator lights, one for the left pitot tube and one for the right pitot tube, are located directly below the control switch and are used to indicate that the pitot tubes are being heated. Two ammeters, one for each pitot electrical circuit, are located on the pilot's console and are used to indicate the amount of current being drawn by the heating elements. Power for the left pitot tube heater circuit is supplied by the 28 volt d-c essential bus and is protected by a 5 ampere circuit breaker which is located on the pilot's circuit breaker panel on the right forward side of the pilots' compartment bulkhead, station 212. Power for the right pitot tube heater circuit is supplied by the 28 volt d-c forward bus and is protected by a 5 ampere circuit breaker located on the main circuit breaker panel on the left aft side of the pilots' compartment bulkhead, station 212.

The pitot tubes are ground checked by turning the "PITOT HEATERS" switch to the "ON" position and noting that both amber indicating lights are illuminated. Also the pitot ammeters should show a current drain of about 6 amperes when the control switch is first turned on and then fall off together to indicate from 4 to 4½ amperes as the pitot tube elements heat.

PITOT TUBE ANTI-ICING SYSTEM OPERATION (See figure 5).

The right and left pitot tube heater circuits are controlled by a single "ON-OFF" switch located on the left side of the overhead switch panel. This switch is the double-pole-single-throw type and when moved to the "ON" position will complete both pitot tube heater circuits. The left pitot tube heater circuit is completed from the 28 volt d-c essential bus through its 5 ampere circuit breaker to the "ON-OFF" control switch. The left pitot tube heater circuit is then completed from the "ON-OFF" switch through the shunt for the left ammeter to the heating element in the left pitot tube. The right pitot tube heater circuit is completed from the 28 volt d-c forward distribution bus through its 5 ampere circuit breaker to the "ON-OFF" switch. The right pitot tube heater circuit is then completed from the "ON-OFF" switch through the shunt for the right ammeter to the heating element in the right pitot tube. Both pitot tube heating elements are grounded to the airplane structure. Two separate circuits, one to each amber indicating light, are also completed from their respective pitot tube heater circuits. Each amber indicating light is connected to a press-to-test circuit which is completed from its respective 5 ampere circuit breaker. Each shunt also completes a circuit to its ammeter.

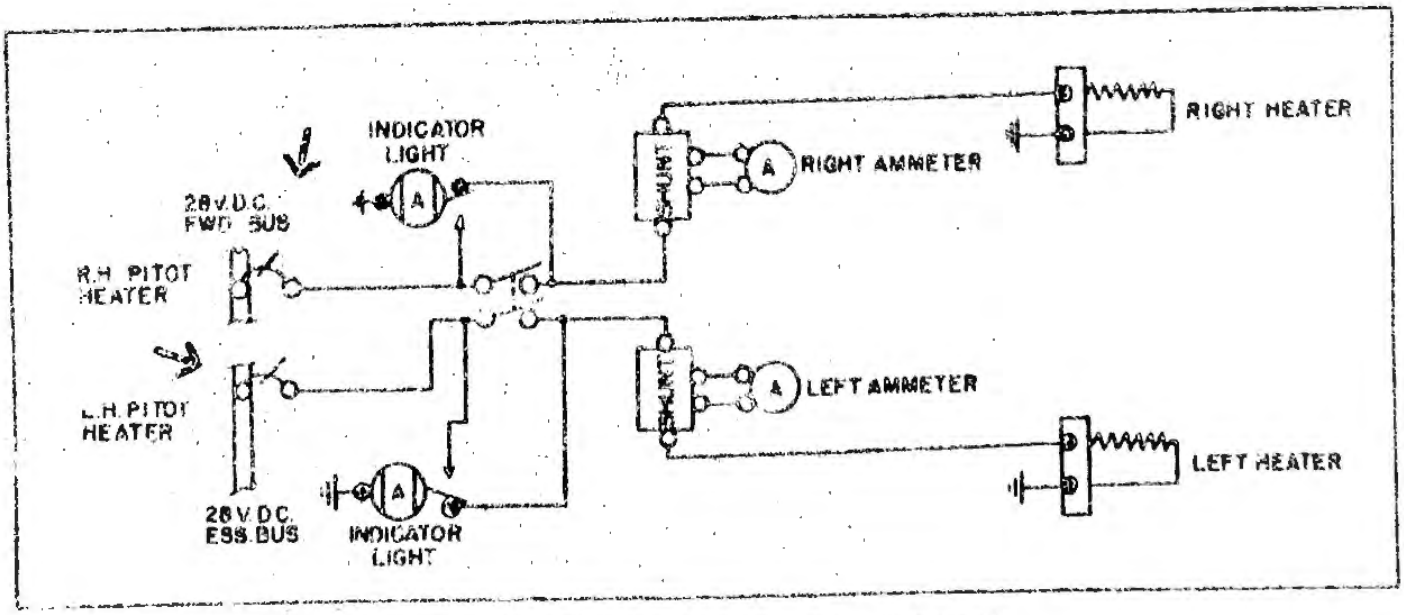


Figure 5. Pitot Tube Anti-Icing Schematic

RAM AIR SCOOP ANTI-ICING - GENERAL
(See figure 10).

The heating and ventilating equipment ram air scoop, which is located on the bottom of the fuselage, is anti-iced by means of three electrically heated rubber blankets. These rubber blankets are cemented to the ram air scoop, one completely around the leading edge, one on the top surface of the vane within the scoop, and one on the scoop interior bottom surface. A single "ON-OFF" control switch for these heating blankets is located on the left side of the overhead switch panel. Included in the ram air scoop anti-icing circuit is a remote control circuit breaker with a thermal trip element. This circuit breaker is located on the left hand distribution panel in the electrical hatch and is used to energize the ram air scoop heating blankets.

Power for the "ON-OFF" control switch is supplied by the 28 volt d-c forward distribution bus and is protected by a 2 ampere circuit breaker. Power for the heating blankets is supplied by the 28 volt d-c left hand distribution bus through the remote control circuit breaker. A switch on the ~~right~~ landing gear scissors strut will prevent the ram air scoop anti-icing system from operating while the airplane is on the ground.

RAM AIR SCOOP ANTI-ICING SYSTEM OPERATION
(See figure 9)

The ram air scoop anti-icing system is put into operation by moving the "AIR SCOOP" control switch on the overhead switch panel to the "ON" position. This will complete the anti-icing circuit from the 28 volt d-c forward bus through its 2 ampere circuit breaker and the control switch to the remote control circuit breaker. With the circuit completed to the remote control circuit breaker, a relay within the unit will be energized, only so long as it is grounded through the nose landing gear scissors switch. This scissors switch will ground the relay only when the weight of the airplane is removed from the landing gear and the oleo shock strut is extended. The energized relay will close a set of contacts and complete a circuit from the left hand distribution bus through a thermal trip unit to the heating blankets.

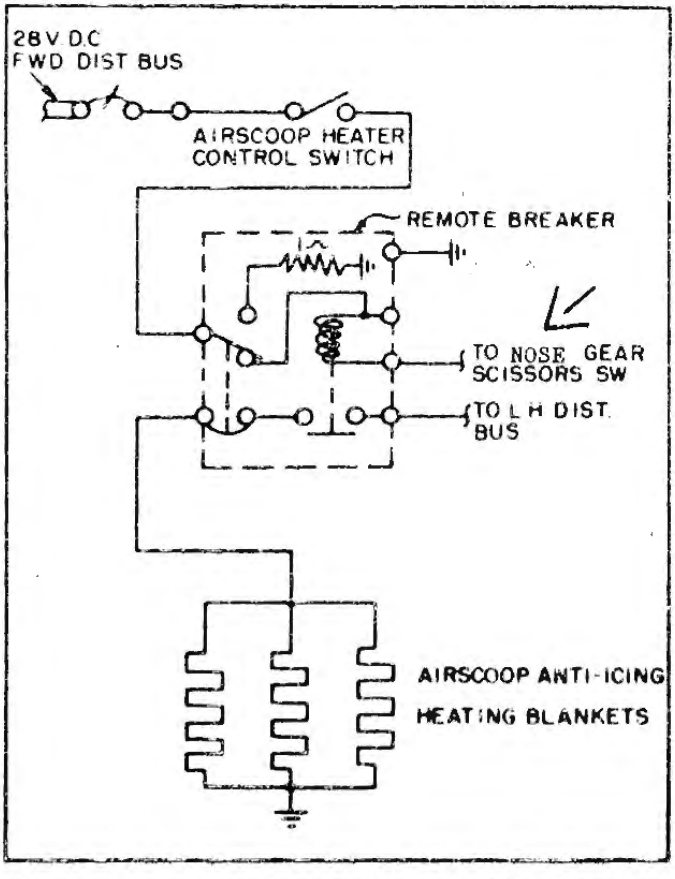


Figure 9. Heating And Ventilating Ram Air Scoop Anti-Icing Electrical Schematic

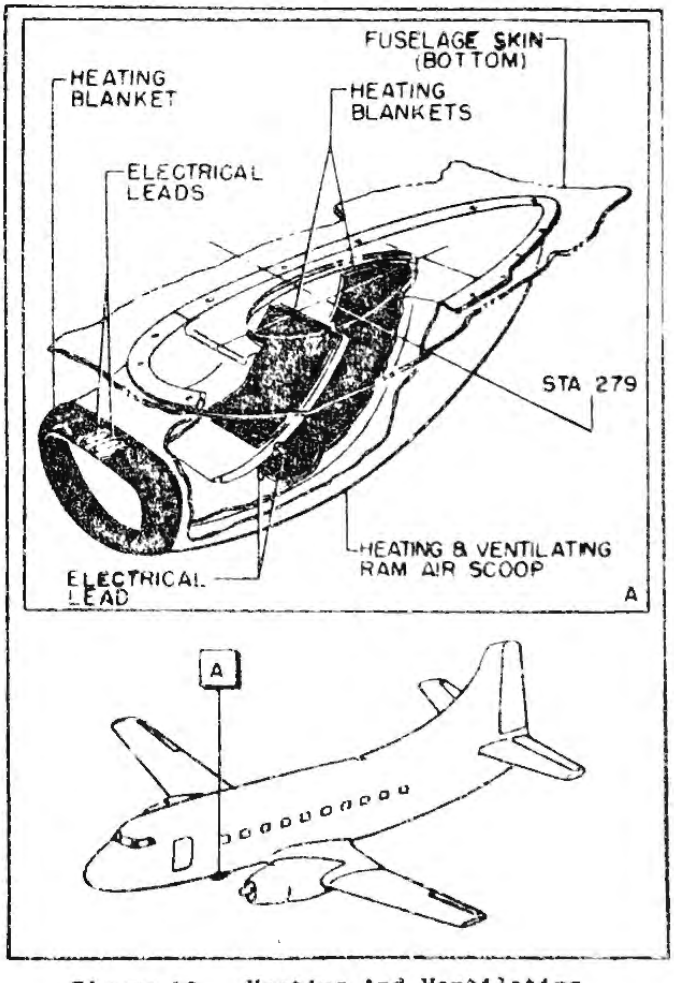


Figure 10. Heating And Ventilating Ram Air Scoop Anti-Icing Installation

WINDSHIELD ANTI-ICING AND WINDOW DE-FOGGING - GENERAL.

Windshield anti-icing and window de-fogging is manually controlled by push-pull controls located to the right of the co-pilot's chair and above the console. Heat for windshield anti-icing is supplied by the cabin heaters which are manually controlled by the "WINDSHIELD ANTI-ICE" control regardless of the cabin temperature demands. De-fogging air for the pilots' compartment windows is supplied by the recirculation air blowers. Refer to Chapter 17 for further information on air conditioning, heating and ventilating.

Windshield Anti-Icing (See figure 30).

Windshield anti-icing is controlled by the operation of two flow control valves, B and B_2. Both valves are interconnected by a non-adjustable link rod and simultaneously operated by the positioning of the "WINDSHIELD ANTI-ICE" control located at the right of the co-pilot's chair. B valve is an iris type valve while B_2 valve is the damper type. A micro switch for operating the cabin heaters is located on the duct directly above B_2 valve and is cam actuated.

When the control is pushed down completely, B_2 valve is wide open, while B valve is nearly closed. A small opening remains in B valve to permit air flow to the windshield and window defogging ducts in addition to the air flow coming through the regulated orifice at B_2 valve. When the control handle is pulled "up", B_2 valve closes and B valve opens to divert air to the windshield ducts. The micro switch on the duct above B_2 valve is actuated in the first 5 degrees of B_2 valve shaft rotation toward the closed position. This actuation of the micro switch completes a circuit to the cabin heaters causing them to operate, provided that the ventilating fans are operating and the heater control switch is in the "AUTOMATIC" position. Operation of the heaters at this time will be the same as if the heater control switch was placed in the "MANUAL" position. This arrangement provides heated air for anti-icing purposes regardless of cabin temperature requirements.

When the windshield anti-icing operation is shut down and cabin heating will not be required, the cabin heaters should be purged. Refer to Chapter 17 for further information on cabin heater purging.

Window De-Fogging (See figure 30).

Pilots' compartment window de-fogging is controlled by the operation of B_1 flow control valve. This B_1 valve is a damper type valve and is located on the right forward side of the pilots' compartment. B_1 valve is operated by the "WINDOW DE-FOG" control located on the same panel as the "WINDSHIELD ANTI-ICE" control. Opening of B_1 valve (control pulled up) will allow recirculated air to be routed to the windows providing the ventilating fans are operating.

ANTI-ICING HEATER TEMPERATURE INDICATING SYSTEM (See figure 15).

The heater temperature indicating gages are located on the lower right side of the pilots' instrument panel. Each gage has three sets of scales and indicating pointers. The upper two scales in the left gage are used to indicate the temperature of the heated air delivered by left nacelle inboard and outboard anti-icing heaters, while the lower scale is used to indicate the temperature of the heated air delivered by the left cabin heater. The upper two scales in the right gage are used for the right nacelle anti-icing heaters and the lower scale for the right cabin heater. The scale range on these indicator gages is from - 20 degrees to + 260 degrees Centigrade.

A temperature bulb is located in the duct at the aft end of each anti-icing heater and is used to pick up and transmit the temperature of the heated air to its respective scale on the temperature indicating gages by means of an electrical circuit. Each temperature bulb has a range of from -50 degrees to + 232.2 degrees Centigrade.

Power for the heater temperature indicating circuit is supplied by the 28 volt d-c forward distribution bus through its "HEATERS TEMP. IND." circuit breakers to the two indicating gages. Individual circuits are then completed from the gages to their respective temperature bulbs. Refer to Chapter 23 for further information on the ratiometer type temperature indicating systems, and to Chapter 26 for wiring diagrams.

ALCOHOL FLUID QUANTITY INDICATING SYSTEM (See figure 16).

The alcohol fluid quantity gage is located in the lower right corner of the instrument panel and is connected by an electrical circuit to the float type quantity indicating transmitter. This electrical circuit is completed from the 28 volt d-c forward distribution bus through its "ALCOHOL QUAN. IND." circuit breaker on the main circuit breaker panel. From this circuit breaker the circuit is then completed to the gage and then to the transmitter. Refer to Chapter 23 for further information on fluid quantity indicating systems, and to Chapter 26 for wiring diagrams of this system.

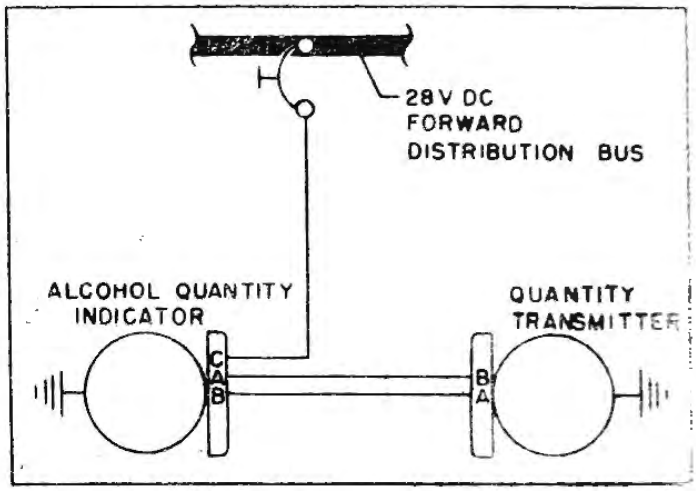


Figure 16. Alcohol Quantity Indicating System

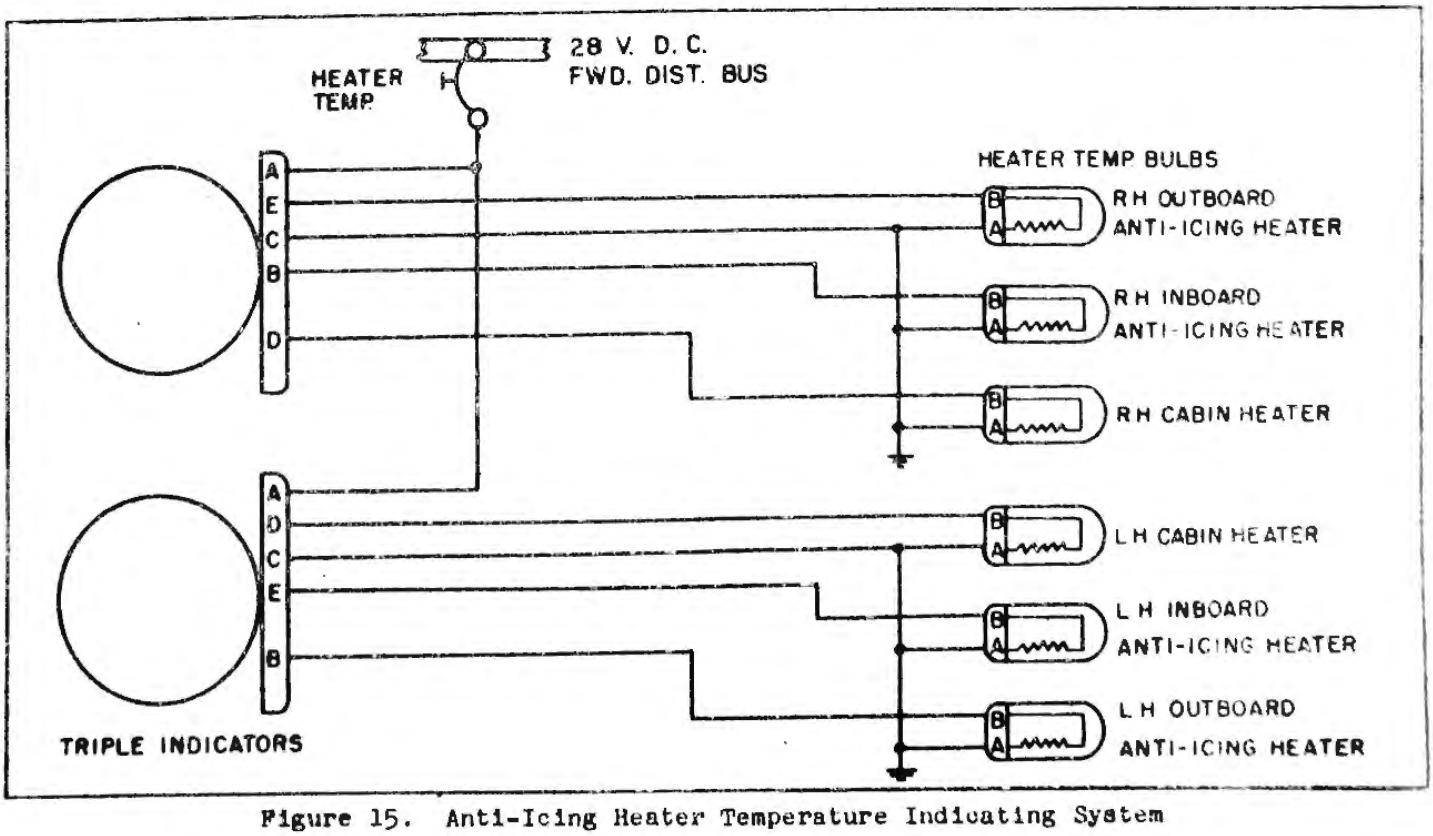


Figure 15. Anti-Icing Heater Temperature Indicating System

WING AND FIN LEADING EDGE DUCT TEMPERATURE INDICATING SYSTEM (See figure 16A).

A temperature indicating system is employed to provide visual indication of the air temperatures in the wing and fin leading edge anti-icing ducts. This system consists of a ratiometer type temperature indicator, mounted on the co-pilot's auxiliary instrument panel; a selector switch mounted above the co-pilot's console; and three resistance bulbs, one each mounted in the left and right wing leading edge at wing station 471 and the vertical fin at station 110. Temperature indications may be obtained from any one of the above ducts by positioning of the selector switch. See Index of Chapter 23 for Temperature Systems General Description and Principles of Operation and Index of Chapter 26 for reference to circuit diagram.

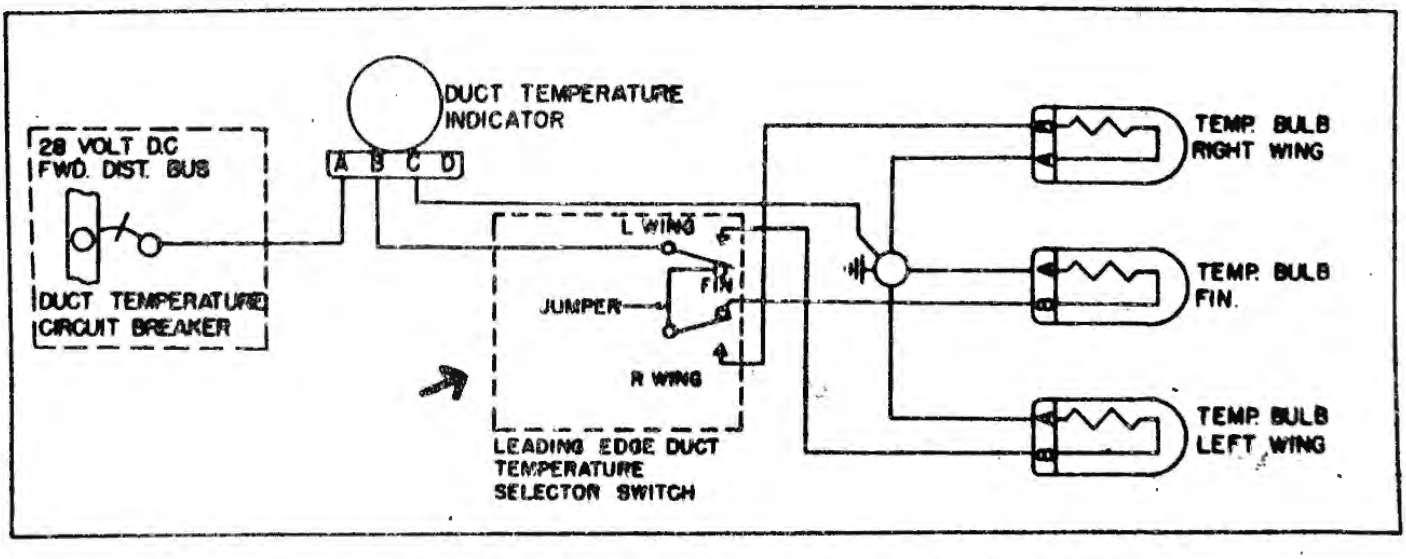
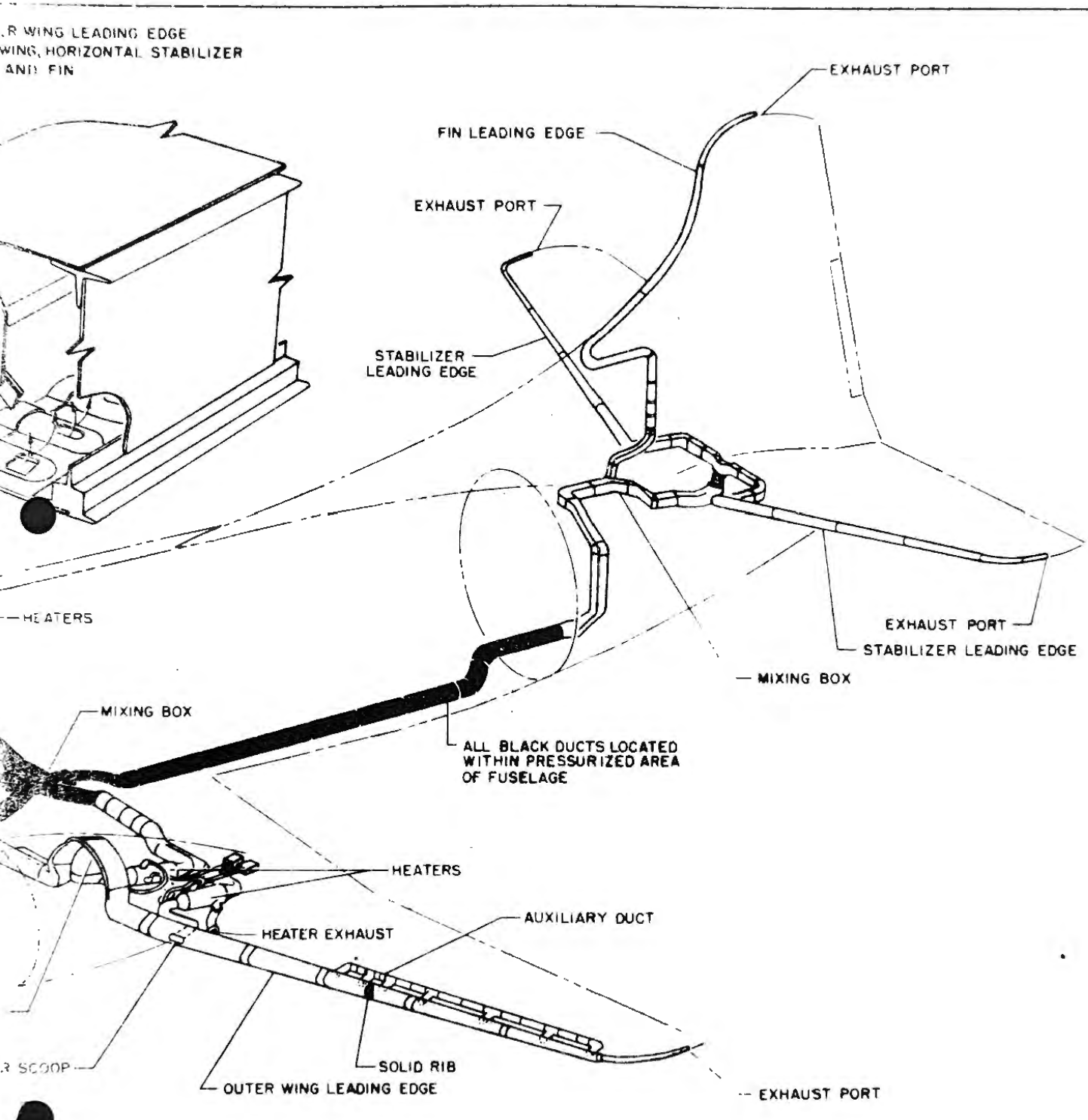


Figure 16A. Wing And Fin Duct Temperature Indicating Schematic


.R WING LEADING EDGE
WING, HORIZONTAL STABILIZER
AND FIN
EXHAUST PORT
FIN LEADING EDGE
EXHAUST PORT
STABILIZER
LEADING EDGE
HEATERS
EXHAUST PORT
STABILIZER LEADING EDGE
MIXING BOX
MIXING BOX
ALL BLACK DUCTS LOCATED
WITHIN PRESSURIZED AREA
OF FUSELAGE
HEATERS
AUXILIARY DUCT
HEATER EXHAUST
R SCOOP
SOLID RIB
OUTER WING LEADING EDGE
EXHAUST PORT

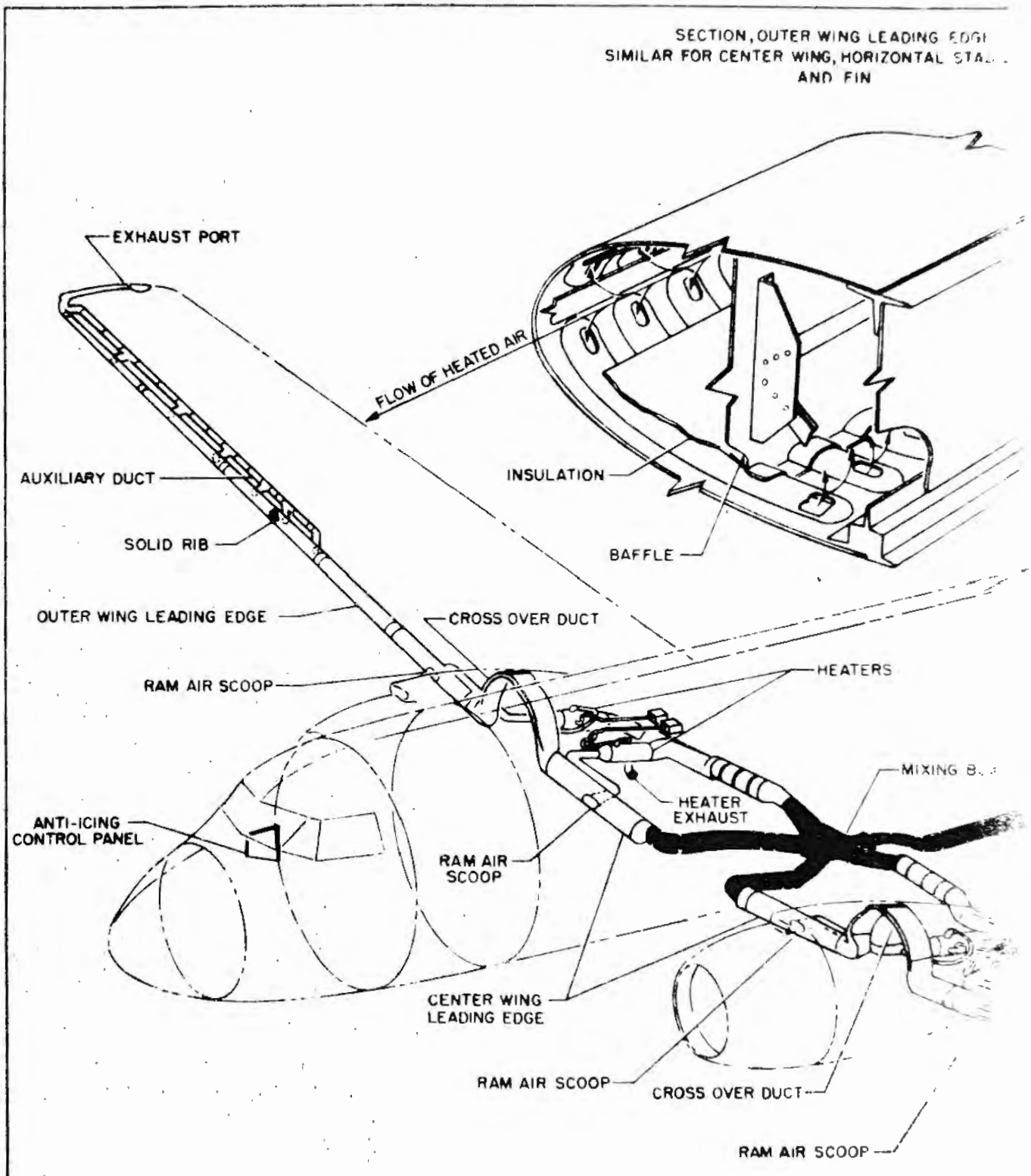


Figure 17. Wing A

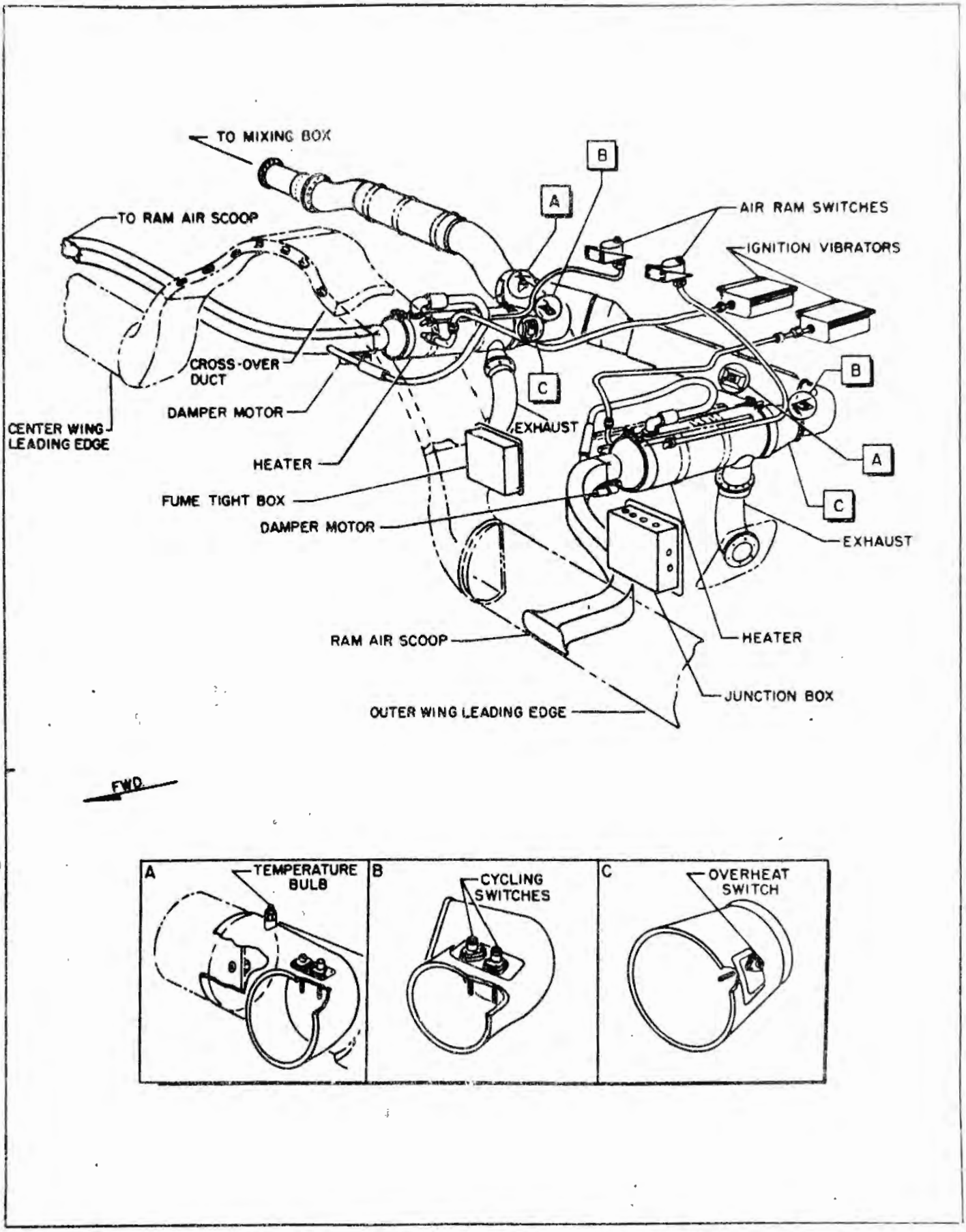


Figure 19. Anti-Icing Installation In Nacelle

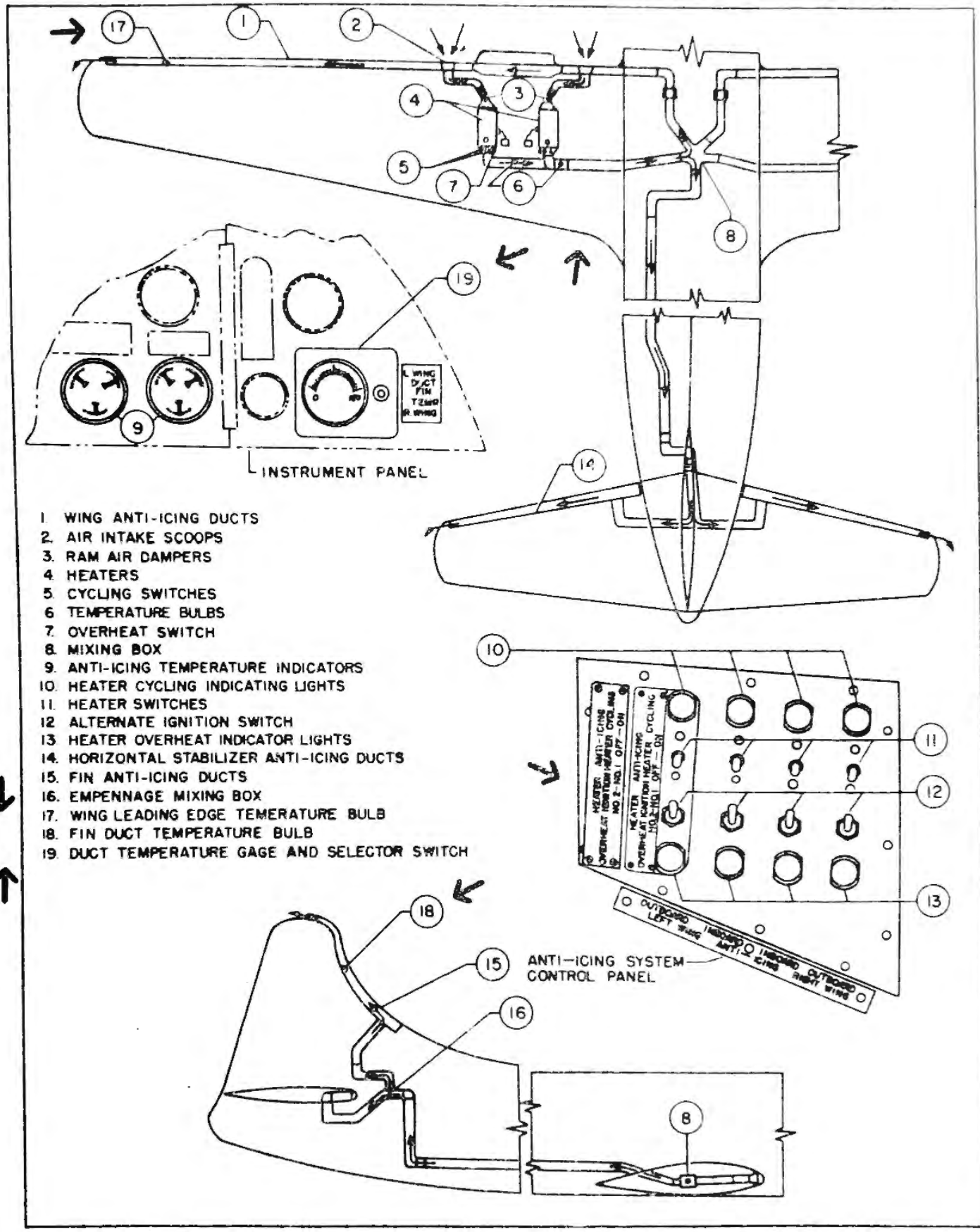
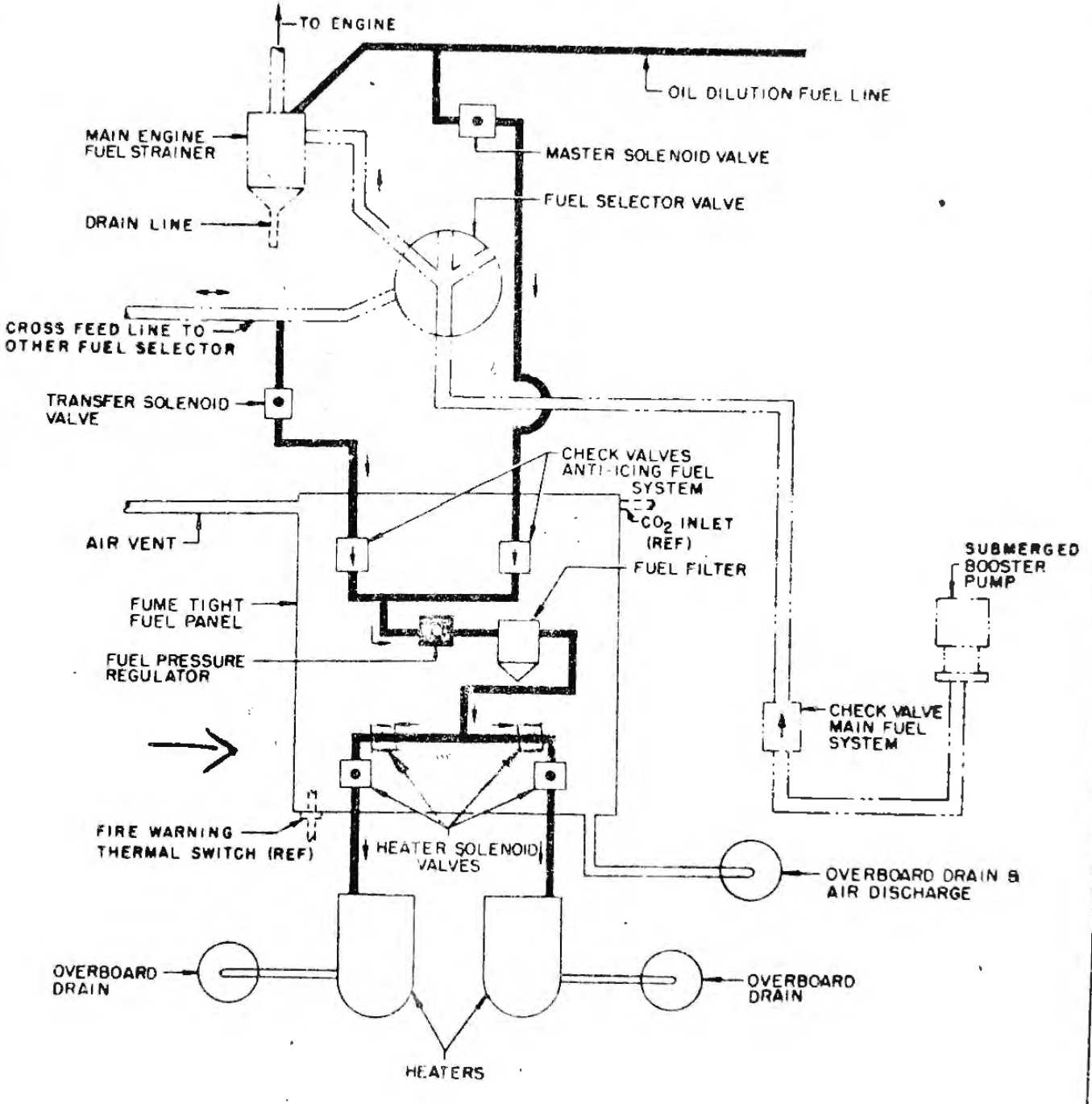


Figure 21. Thermal Anti-Icing System Schematic



NOTE:
SYSTEM SHOWN IS FOR HEATERS IN R H NACELLE
L H SYSTEM SIMILAR

Figure 23. Anti-Icing Fuel System Schematic

FIRE DETECTION AND EXTINGUISHING
GENERAL DESCRIPTION

FIRE DETECTION AND EXTINGUISHING - GENERAL.

Each nacelle is equipped with two fire protection systems. The fire detection and warning system detects the presence of fire in the protected areas and relays this information to the pilot's compartment by means of a warning bell and warning lights. The fire extinguisher system extinguishes the fire by smothering it with carbon dioxide.

FIRE DETECTION AND WARNING SYSTEM - GENERAL

The protected areas of the nacelle are divided into zones. Zone 1 consists of that area forward of the engine mount ring. Zone 2 extends from the firewall to the engine mount ring. Zone 3 comprises that area between the firewall and the front spar. Zone 3-A is the area between the front and rear spars (anti-icing heaters). Zone 4 is the only area that is not provided with fire extinguishing equipment. The protected areas in the fuselage are the belly cargo compartment, the cabin heaters and fuel fume-tight box. (See figure 7).

The Edison Type a detector system is used for fire indication in Zones 1, 2, 3, and 3-A and thermal thermoswitches are used for the engine exhaust system in zone 1, and the cabin heater and anti-icing heater fuel fume tight boxes.

Nine dual indicator lights are mounted on the pilots glare shield and these lights, along with warning bell comprise the warning system. The operation of the system can be tested by a two-position switch on the overhead switch panel.

OPERATION OF FIRE DETECTION AND WARNING SYSTEM. (See figure 7).

When a fire occurs in a protected zone, the "hot" junction of the detector tube generates an electromotive force which causes current to flow to its respective sensitive relay. The coils in the sensitive relay are energized, and in turn energize the slave relay, which completes the airplane circuit to the indicator lights and warning bell. The relays pull in, completing the circuit to the warning bell.

The thermoswitches work on a rise in temperature principle. When the temperature at the thermoswitch reaches 450±20°F the switches close and complete the circuit to the warning lights and bell.

Power for the operation of the detection and warning system is taken from the forward distribution panel. The circuit breakers on the main circuit breaker panel read "FIRE DETECTION WARNING BELL" and "ENGINE FIRE DETECTION".

Thermal Test Unit. - Edison Type (See figure 8).

The thermal test unit consists of a thermocouple with a pair of heating coils adjacent to its "hot" junction. This mechanism is sealed in a glass bulb which has a four-pin type base for mounting in the relay panel. When the "FIRE DETECTOR TEST" switch is operated the heating coil heats the thermocouple, and if the detector circuit is closed, the fire warning signal will be given.

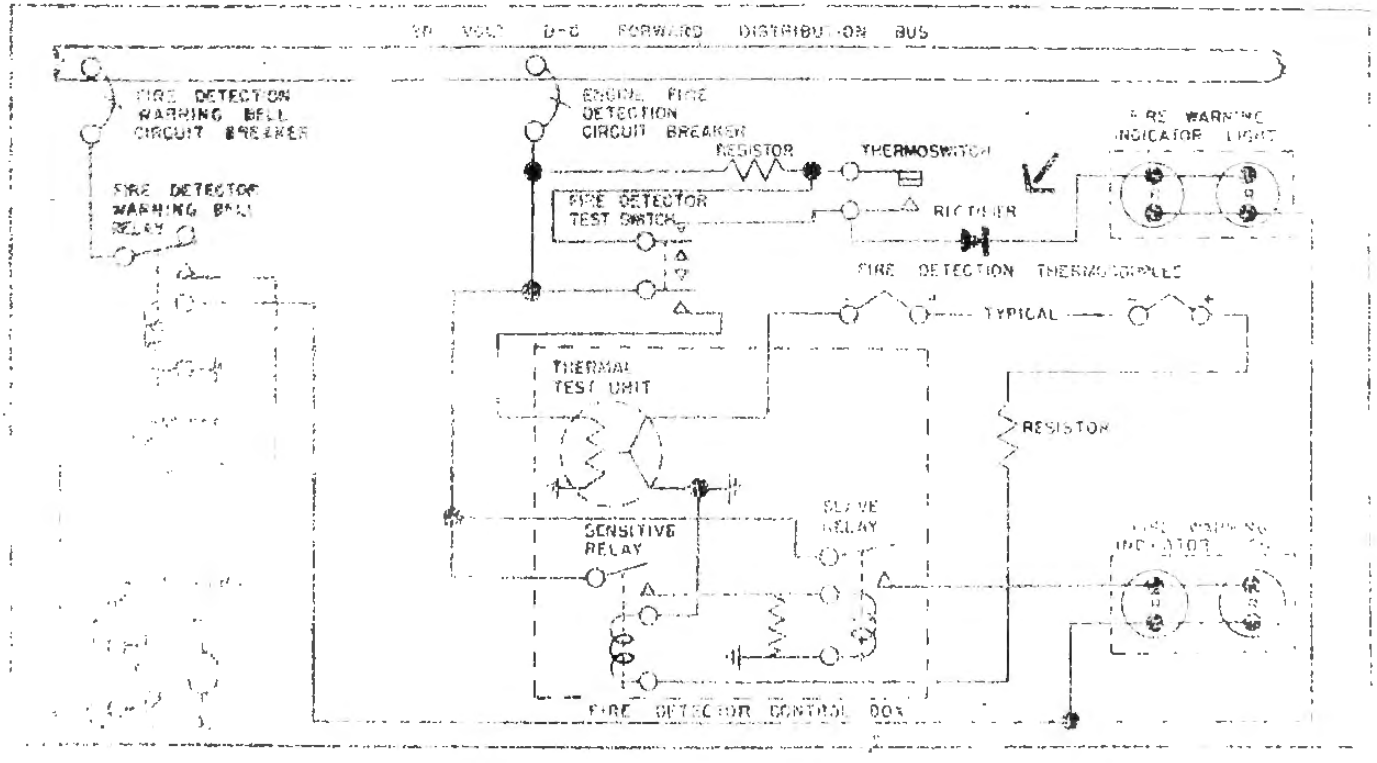


Figure 1. Basic Circuit For Fire Detection System

Thermal Test Unit. (Cont.)

If the thermal unit is faulty it can be replaced by merely pulling it out of its mounting in the relay panel which is mounted in the "FIRE DETECTOR CONTROL BOX", located directly above the heater access hatch.

CAUTION

When replacing this unit be sure contact pins, on base of the replacement, are not forced into incorrect socket holes as this would render the system inoperative.

Test Switch And Indicator Lights. (See figure 9).

Two test switches are mounted on the overhead switch panel. These are two-position switches for checking the detector system for operation. Placarding is as follows:

FIRE DETECTOR TEST
ZONES 1-2-3
SYSTEM 1

SYSTEM 2
ZONE 1 AND HEATERS

Dual fire warning lights are provided for each circuit and are located above the corresponding selector handles in the glare shield.

CAUTION

Use only AN 3121-313 bulbs to insure proper operation of the warning system.

Fire Detectors - Edison Type (See figure 8).

Cage-type detectors are used in zones 1, 2, and 3. The thermocouple wires are mounted in a heat resistant insulator and surrounded by a stainless steel cage which has openings in it to allow heat to reach its "hot" junction. All the detectors in any zone are wired in series. When replacing a detector, note which wire is connected to the identified positive (+) terminal of the defective unit and connect the replacement in the same manner.

CAUTION

Output from a reversed thermocouple will not only fail to operate the system, but will tend to counteract the output of the other thermocouples.

The detectors are mounted in various locations in the engine nacelles. Refer to Series 3 for quantities in each zone and to figure 11 for the approximate location.

Sensitive Relay.

The relay is energized by the current generated by the thermocouples. The moving part or armature, has a small magnet vane at its lower end and a hairspring, balance cross with weights, and contact arm at its upper end. The magnet vane is positioned between two stationary coils. When the coils are energized by current from the thermocouples, the armature turns in its jeweled bearings, causing its contact arm to touch a stationary contact wire. The hairspring serves to carry the secondary current to the contact arm, and also returns the armature to its original position when the energizing current ceases to flow. The entire mechanism is encased in an aluminum cover and is mounted in the relay panel by a 7-pin type base. Malfunctioning of this unit is cause for replacement.

Slave Relay.

The load carrying ability of the sensitive relay is too small to operate the warning bell. Therefore, a slave relay mounted in the relay panel is employed. This slave relay is energized by the sensitive relay and supplies current to the warning bell and fire indicator lights.

Master Warning Bell.

A warning bell is mounted adjacent to the landing gear warning horn in the co-pilots console. The bell is attached with three bolts for easy removal. This bell sounds whenever the detectors or thermoswitches detect a fire or when the "FIRE DETECTOR TEST" switch is closed. A "FIRE WARNING SHUT OFF" switch is mounted on the overhead switch panel to turn the bell off if desired.

Warning Bell Relay.

Two warning bell relays are mounted in the "BELLY ELECTRICAL JUNCTION BOX" which is accessable through the heater access hatch. These relays receive their positive feed from the forward distribution bus through the "FIRE DETECTION WARNING BELL" circuit breaker, located in the main circuit breaker panel on the aft side of station 212. The circuit to the warning bell is completed through these relays whenever the fire warning divices are actuated or the "FIRE DETECTOR TEST" switch is closed

Resistors And Rectifiers.

Five 25 ohm-40 watt resistors and two rectifiers are mounted in the "BELLY ELECTRICAL JUNCTION BOX", accessable through heater access hatch. Two 10 watt 1 ohm resisters are provided, one each in left and right distribution panel. Their purpose is to isolate the wiring between fire zones so that if a fire destroys or shorts out the thermoswitch wiring in one zone, the fire detector circuits in the other zones will still function satisfactorily.

Thermoswitch Fire Detector - Fenwal.
(See Figure 2).

A total of seven thermoswitches are provided; one at the cabin heater fuel fume-tight box, located in the cabin heater compartment, one at each anti-icing heater fuel fume-tight box located in Zone 3A in the nacelle, one at each inboard and outboard exhaust shroud both left and right engines. These switches will close when the temperature exceeds 450 ± 25° F. and close the circuit to the indicator lights and warning bell.

CAUTION

When replacing a thermoswitch, do not apply more than six inch-pounds torque to terminal stud nor more than 12 inch-pounds torque to hex head of the thermoswitch.

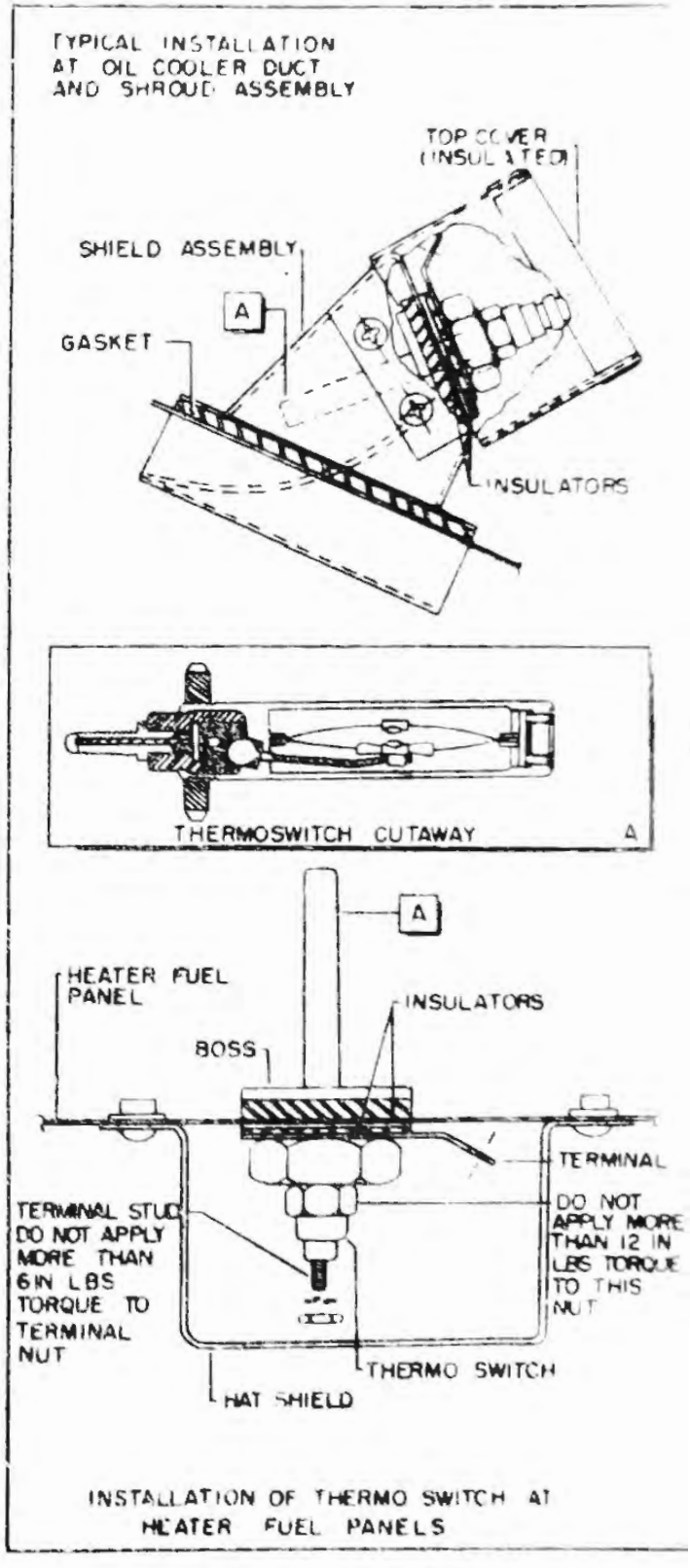


Figure 2 Thermoswitch Fire Detector

Fire Extinguishing - General.

The airplane is equipped with a manually operated, two-shot, carbon dioxide fire extinguishing system. This system is used to extinguish fires in nacelle zone 2, 3, 3A, belly cargo and cabin heater compartments. In addition, three portable, hand-operated fire extinguisher bottles, of two pounds carbon dioxide capacity each are provided. The portable carbon dioxide bottles are located as follows: one on the forward side of the pilots' compartment door; one right above the center section radio rack in the galley (near the crown of the airplane); and one located on the forward side of the aft cabin bulkhead (behind the last passenger seat on left side).

The components of the fire extinguishing system consist of the control handles, four large carbon dioxide bottles and operating heads, six pilot control valves, four flood valves, two double check tees, six stop valves, two lockout valves, two vent check valves, discharge (manual and thermal) indicators and necessary plumbing. The firewall shut-off valve is considered to be a part of this system. Refer to Chapter 4 for the crash-axe and first aid kit.

OPERATION OF THE FIRE EXTINGUISHING SYSTEM. (See figure 7).

When a "SELECTOR" handle is pulled, it operates a pilot cable control valve which controls the operation of a stop valve. When the "CO_2 DISCHARGE" handle is pulled, it fires a bank of bottles which are filled with liquid carbon dioxide under pressure. The escaping carbon dioxide, in a gaseous form fills the supply line up to each of the six stop valves. Since the pilot control valve has permitted only one stop valve to open, the carbon dioxide will be routed to the selected area. The pilot control valve and the stop valve will automatically reset to "closed" after discharge. Due to a locking arrangement, it is not possible to pull a "CO_2 DISCHARGE" handle until one of the "SELECTOR" handles has been pulled.

SELECTOR HANDLES (See figure 9).

The selector handles, mounted on the glare shield are Teleflex controls with the exception of the "SELECTOR ZONE 2 - FIREWALL SHUT-OFF" which is a cable control. All the selector handles, with the exception of "SELECTOR BELLY CARGO" perform other functions in addition to operating their respective pilot control valves.

"SELECTOR ZONE 2 - FIREWALL SHUT-OFF" Selector Handles (See figure 13).

The "SELECTOR ZONE 2" right and left handle controls the fuel, oil hydraulic and water injection shut-off valve at each firewall. Pulling the handle to extended position closes the firewall shut-off valve, opens the pilot control valve, also actuates a micro switch which opens the [illegible] circuit of its respective engine.

With "SELECTOR ZONE 2" handle extended a split discharge would occur if any zone, except zone 3 is selected and the bottles fired. Therefore to prevent a split discharge and allowing the firewall shut-off valve to remain closed, "SELECTOR ZONE 2" handle should be pushed in to the detent position, which closes zone 2 pilot control valve only. The firewall shut-off valve control quadrant is slotted to allow for this travel. A lock-out valve is provided in the zone 2 pressure line to prevent a split discharge between zone 2 and zone 3. Refer to zone 2 lock-out valves.

"SELECTOR ZONE 3 - ANTI-ICING HEATERS" Selector Handles (See figure 13).

"SELECTOR ZONE 3" right and left handles control their respective pilots control valves and micro switches. The micro switch, when energized, closes the anti-icing intake duct damper, the anti-icing fuel shut-off valves and de-energizes the fuel booster pump unless the pump is operating through the "FUEL BOOSTER PUMP" switches on the overhead switch panel. "SELECTOR ZONE 3" handle also closes the zone 2 lock-out valve. Refer to Chapter 26 for wiring diagrams.

"SELECTOR CABIN HEATER FUEL" Selector Handles. (See figure 13).

The "SELECTOR CABIN HEATER FUEL" handle controls its respective pilots control valve and micro switch. The dual micro switch when actuated performs the following.

a. One switch establishes a ground circuit for the coil of the cabin heater cut-off relay. Which in turn opens the circuits of the fuel cycling solenoid, ignition, combustion air blower and recirculation air blower.

b. The second switch opens the control circuit to the master fuel solenoid valves, which cuts off fuel supply to both cabin heaters.

Refer to Cabin Heater Chapter 17 and Chapter 26 for wiring diagrams.

"SELECTOR BELLY CARGO" (See figure 13).

Pulling "SELECTOR BELLY CARGO" handle to extended position will open the pilot control valve, thus allowing pressure to operate the respective stop valve releasing the agent into the belly cargo area when the bottles are fired.

"CO_2 DISCHARGE" Handles (See figure 13).

A "CO_2 DISCHARGE" handle is located on the extremities of the fire detection and extinguishing

"CO2 DISCHARGE" Handles (Cont.).

section of the glare shield. The left handle operates the left bank of bottles and the right handle operates the right bank of bottles. These handles operate cables which are connected to a cable tensioning device in the fuselage belly (near the bottles). This tensioning device helps to maintain the cables at 12 pounds tension. A short cable is installed between the tensioning device and the operating heads of the bottles by means of a quick disconnect fitting. See Fire Extinguishing System Controls Adjustment Procedure for rigging of all cables and controls. Due to a locking device between the selector handles and discharge handles it is necessary to pull a selector handle before pulling a discharge handle. This is to prevent discharge of CO2 bottles into a closed system. Either bank of bottles may be fired to any selected zone.

CARBON DIOXIDE BOTTLES (See figure 15).

The four carbon dioxide bottles, each containing a 9.5 pound charge, are connected in vertical banks, two each at either side of fuselage center line a station 532 and are accessible through the rear spar access hatch #86 in the fuselage belly. Each bank of bottles is connected to a double check tee in the discharge manifold and can be fired separately. The double check tee prevents the passage of carbon dioxide into the other bank of bottles when one bank has been discharged. The bottles may be removed by disconnecting the plumbing and control cable and removing the clamp at the neck of each bottle. A quick disconnect is provided for the control cable. See CO2 Bottle Replacement.

Each bottle has a flood valve and control head attached to it. An external means is provided for indicating when a bottle has been discharged manually or thermostatically.

Flood Valves (See figure 15).

A flood valve is screwed directly into the neck of each bottle. This valve incorporates a pilot check valve which is held against its seat by gas pressure. When the cable control head is actuated, it forces the pilot check down which allows a small quantity of carbon dioxide gas to escape through drilled passages to the piston. Thus, the flood valve utilizes the carbon dioxide pressure within the bottle to effect its own release.

Each flood valve has a thermal relief valve. If excessive pressure builds up in the bottle due to heat, the relief valve will allow the carbon dioxide to discharge overboard. This escaping carbon dioxide will rupture a red discharge indicator disc in the fuselage skin near the left wing fillet at fuselage station 615. These discs are held in place by snap rings and are replaceable from outside the airplane. If inspection of these discs shows them to be ruptured, the system should be checked. Install new disc. Refer to CO2 Bottle Replacement for further information.

Series Cable Control Heads (See figure 3).

A series cable control head is mounted directly on top of the flood valve and is operated by the "CO2 DISCHARGE" handle in the cockpit. These control heads in a bank of bottles are interconnected so that both bottles will be fired simultaneously. A cable quick disconnect is provided at the bottles to permit removal of resetting of the control heads. When the bottles are discharged, a small quantity of carbon dioxide is ported to a discharge indicator, near fuselage station 615 (See figure 15). This small quantity of carbon dioxide drives a piston which ruptures the yellow discharge indicator. If inspection of these indicator discs shows them to be ruptured, the bottles and system should be checked, and bottles replaced.

Zone 2 Lock-Out Valves (See figure 13).

Two lock-out valves are located forward of the glare shield at fuselage station 129. These valves are normally open and are closed by

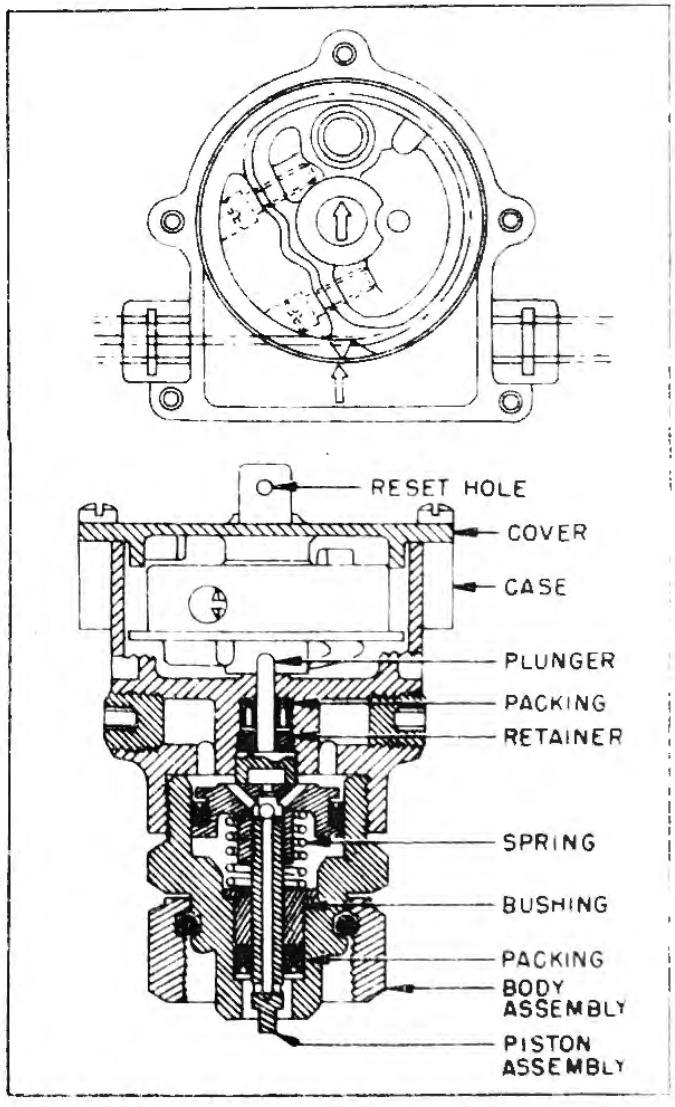


Figure 3. Series Cable Control Head

Zone 2 Lock-Out Valves (Cont.).

pulling "SELECTOR ZONE 3" handle. These valves will prevent a split discharge in the event the "SELECTOR ZONE 2" has been pulled to close the firewall shutoff valve.

Stop Valves (See figure 7).

A stop valve is provided for each of the six protected zones. Each valve is normally closed and is controlled by the pilot control valve. When the carbon dioxide bottle is discharged, the gas will fill the supply line to each stop valve and will therefore only pass through the stop valve which has been opened by the pilot control valve (selector handle operates the pilot control valve). Each valve is attached with four bolts for ease of replacement.

A stop valve for Zone 2 is located on the right hand side of each nacelle, approximately 16 inches forward of the front spar and is accessible through the main wheel well. A stop valve for zone 3 is in the leading edge of each wing, just inboard of the nacelles and approximately three inches forward of the front spar. Access to the valves may be gained by removing the cover plates, bottom side of leading edge cargo compartment stop valve is located below the floor, just to the left of the fuselage center line at station 520. Access to the valve and CO_2 bottles is gained through the rear spar access door. The stop valve for the cabin heater is located just below the floor at fuselage station 360 and is accessible through the electrical access hatch.

Pilot Cable Control Valves.(See figure 4)

Six pilot control valves are provided, one for each of the four selector control handles, one for each CO_2 discharge control handle, which are located forward of the glare shield at approximately fuselage station 149 and are accessible through the nose wheel well. Each valve is normally closed and is opened by pulling its respective control handle. These valves control the stop valves and automatically reset after operation.

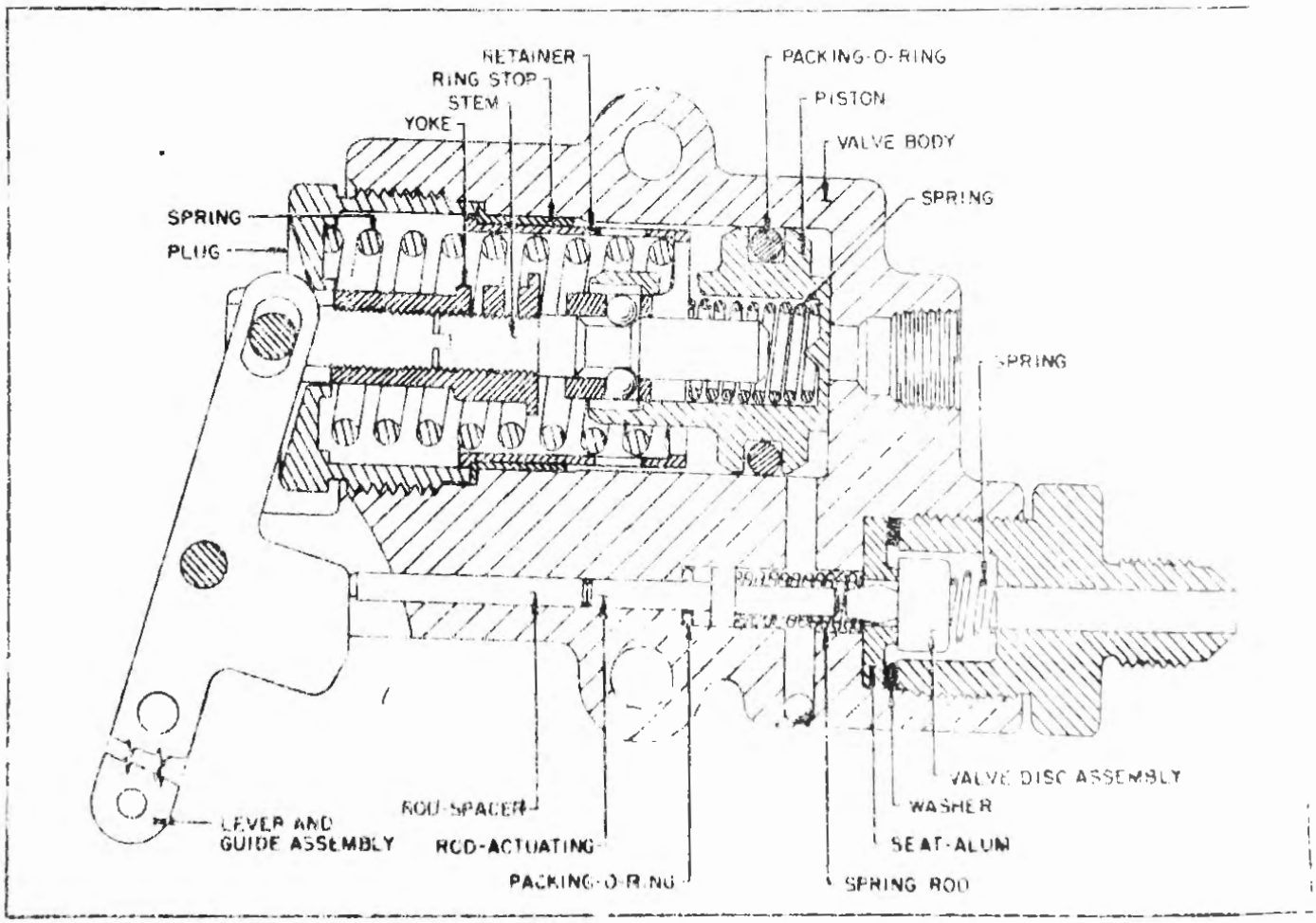


Figure 4. Fire Extinguisher Pilot Cable Control Valve

Vent Check Valves (See figure 15).

A vent check valve is installed in the manual discharge line of each bank of bottles. This valve is normally open and closes at 75 psi. Its function is to prevent pressure from building up due to leakage of double check tee.

Double Check Tee (See figure 15).

A double check tee is installed in the center of the manifold discharge line between the two banks of bottles. When one bank of bottles is fired this valve checks the passage of carbon dioxide from entering the lines of the opposite bank. Another double check tee is mounted just forward of the manifold discharge line. This tee is used for checking the system by an external source.

CARBON DIOXIDE DISTRIBUTION SYSTEM
(See figure 7).

The distribution system is made of aluminum tubing in the unprotected areas and corrosion resistant steel tubing and flame resistant hose in the protected area.

Outlets in the protected areas are of two types; tubular spray nozzles consisting of tubing plugged at one end with outlet holes staggered along its length, and fitting nozzles consisting of tube fittings of various size orifices. The spray type is used to flood whole areas and the nozzle type is used to direct the carbon dioxide to individual units in the area.

Zone 2 - Engine Mount Ring to Firewall.

This zone has a tubular spray outlet ring to flood the area and four fitting nozzles located in the carburetor air scoop, oil cooler duct, generator blast tube and compressor oil cooler duct (R.H. side only).

Access doors which open inward under pressure are provided in the engine accessory cowling for insertion of portable fire extinguisher nozzles to afford additional fire protection when airplane is on the ground.

Zone 3 - Firewall To Front Spar - Main Landing Gear Well.

This zone has a tubular distributor with spray openings.

Zone 3A - Front Spar To Rear Spar.

This zone has a tubular spray outlet to flood the area and three nozzle outlets; one each in the combustion air discharge duct of each heater and the heater fuel fume tight box.

Cabin Heater Compartment Zone.

The cabin heater compartment has three spray nozzles, one each located in combustion air discharge duct of each heater and the heater fuel fume tight box.

Belly Cargo Compartment Zone.

This area has a tubular spray nozzle to flood the entire compartment.

FIREWALL SHUT-OFF VALVES (See Figure 5).

The firewall shut-off valve assembly is mounted on the aft left hand side of the firewall in each nacelle and is accessible through the main gear wheel wells for inspection and rigging. The lower portion of the assembly is a combination fuel, oil and hydraulic valve. These valves are mounted one on top of the other, combined into a single unit, and operated simultaneously by a single control shaft. Bleed holes are provided to help ascertain which valve is at fault when seepage is present. The control quadrant is mounted above the valve and the water injection shut-off valve is mounted above the quadrant. A shaft extends through the control quadrant and meshes with the yoke of each valve assembly. When the "SELECTOR ZONE 2-FIREWALL SHUT-OFF" handle is pulled out, the control quadrant is rotated which in turn closes the valves

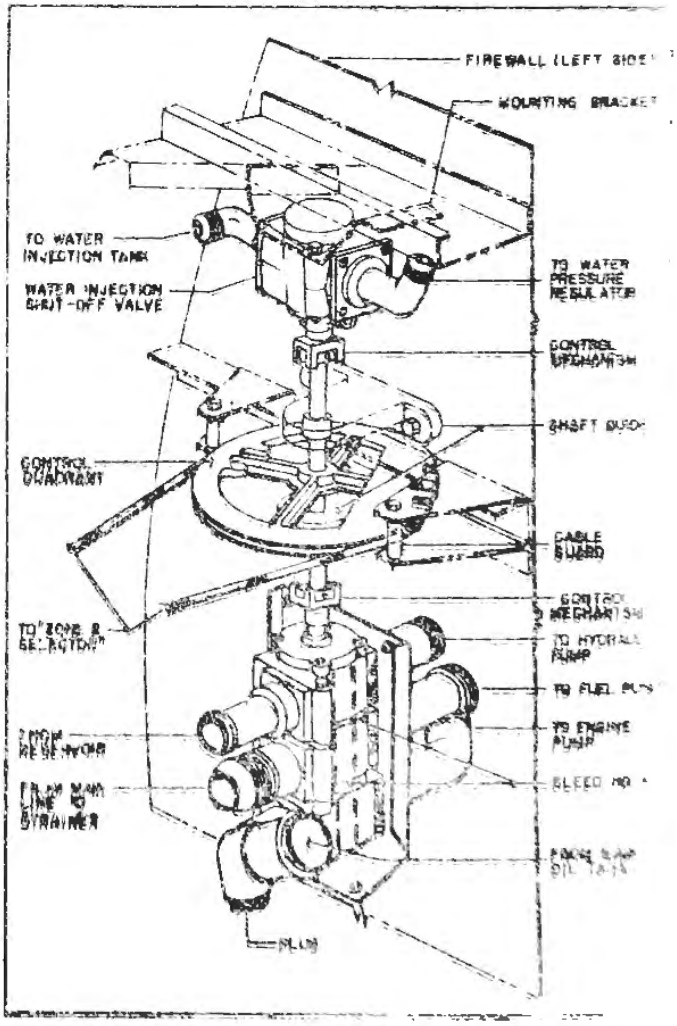
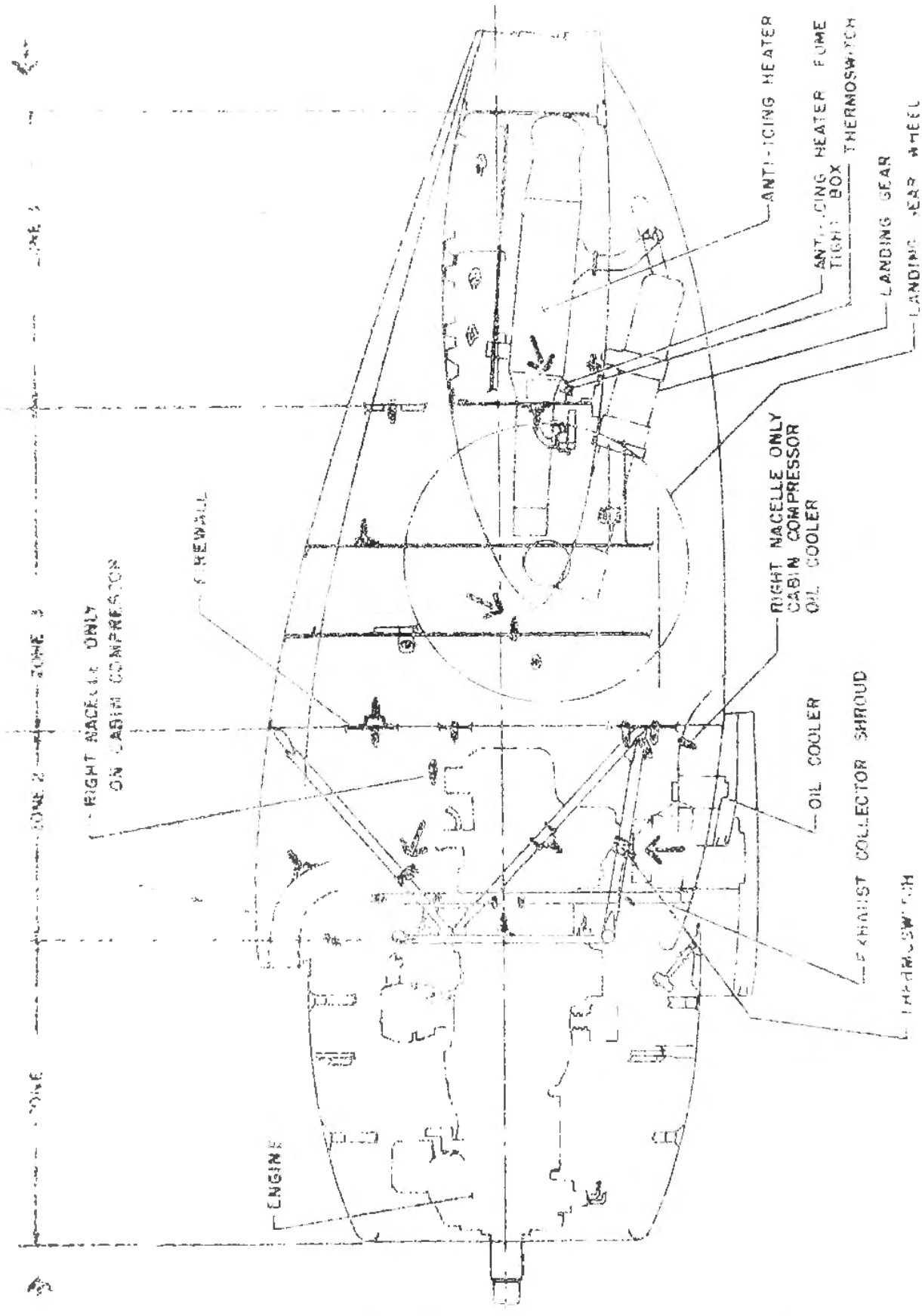


Figure 5. Firewall Shut-Off Valves

COCKPIT PULL HANDLES
CO2 DISCHARGE
ZONE 2
ZONE 3
AUX
FUEL
CABIN HEATER
CARGO
AUX
ZONE 3
ZONE 2
CO2 DISCHARGE
WARNING LIGHTS
MICRO SWITCHES
TELEFLEX CABLES FOR SELECTION
CABLE CONTROLS FOR SELECTING AND FIRING
CARBURETOR AIR SCOOP NOZZLE
POWER SECTION ZONE 1
ACCESSORY SECTION ZONE 2
WHEEL WELL ZONE 3
ANTI-ICING HEATERS ZONE 3A
ZONE 2 LOCKOUT VALVES
ENGINE OIL COOLER AND GENERATOR BLAST NOZZLE
FIREWALL SHUT-OFF VALVE
FUEL FUME-TIGHT BOX NOZZLE
PILOT CABLE CONTROL VALVES
COMPRESSOR OIL COOLER NOZZLE
FUEL FUME-TIGHT BOX NOZZLE
½" STOP VALVE
ACCESSORY SECTION RING
ZONE 3 DISTRIBUTOR
¼" STOP VALVE
FRONT SPAR
FUEL FUME-TIGHT BOX NOZZLE
COMBUSTION AIR NOZZLES
REAR SPAR
½" STOP VALVE
ANTI-ICING HEATERS
GROUND TEST CONNECTION
CABLE QUICK-DISCONNECT
¼" DOUBLE CHECK TEE
CABLE TENSION DEVICE
VENT CHECK VALVES
OVERHEAT DISCHARGE INDICATOR
MANUAL DISCHARGE INDICATOR
SERIES CABLE CONTROL HEAD
BELLY CARGO AREA
CO2 CYLINDER (9.5 cu.in.) AND FLOOD VALVE

Figure 9. Fire Detection And Extinguishing Indicators And Controls


ANTI-ICING HEATER
ANTI-ICING HEATER FUME
TIGHT BOX
THERMOSWITCH
LANDING GEAR
LANDING GEAR WHEEL
RIGHT NACELLE ONLY
CABIN COMPRESSOR
OIL COOLER
FIREWALL
RIGHT NACELLE ONLY
ON CABIN COMPRESSOR
OIL COOLER
EXHAUST COLLECTOR SHROUD
ENGINE

Carbon Dioxide Bottles.

Capacity — 9.5 pound charge in each of four bottles

Operating Pressure 800 lbs at 68 degrees. (Will vary with temp. change).

The CO_2 cylinders shall be stenciled "RIGID SYPHON" as it is mounted upright. The weight tolernace on the cylinder charge is 9 lb. 5 oz. + 0 - 3 oz. for receiving inspection and 9 lb. 8 oz. + 0 - ½ oz. at inspection during service.

Cable Tensioning Device.

Spring rated at 12 pounds.

Fire Detectors.

Quantity and location

Zone	Right Hand	Left Hand
1	11	11
2	14	12
3	16	15

Thermoswitches.

Set to operate at 450 ± 25°F.

Quantity and location.

1 in each anti-icing heater fuel fume-tight box.

1 in cabin heater fuel fume-tight box.

1 at each engine exhaust outlet (2 per engine)

Carbon Dioxide Discharge Indicators.

Thermal	Red
Manual	Yellow

Cable Tension (corrected to standard temperature)

Firewall shut off	40 ± 5 pounds
CO_2 Discharge	12 pounds

Torque Values.

Thermoswitch

Terminal stud	6 inch pounds maximum
Hex head	12 inch pounds maximum

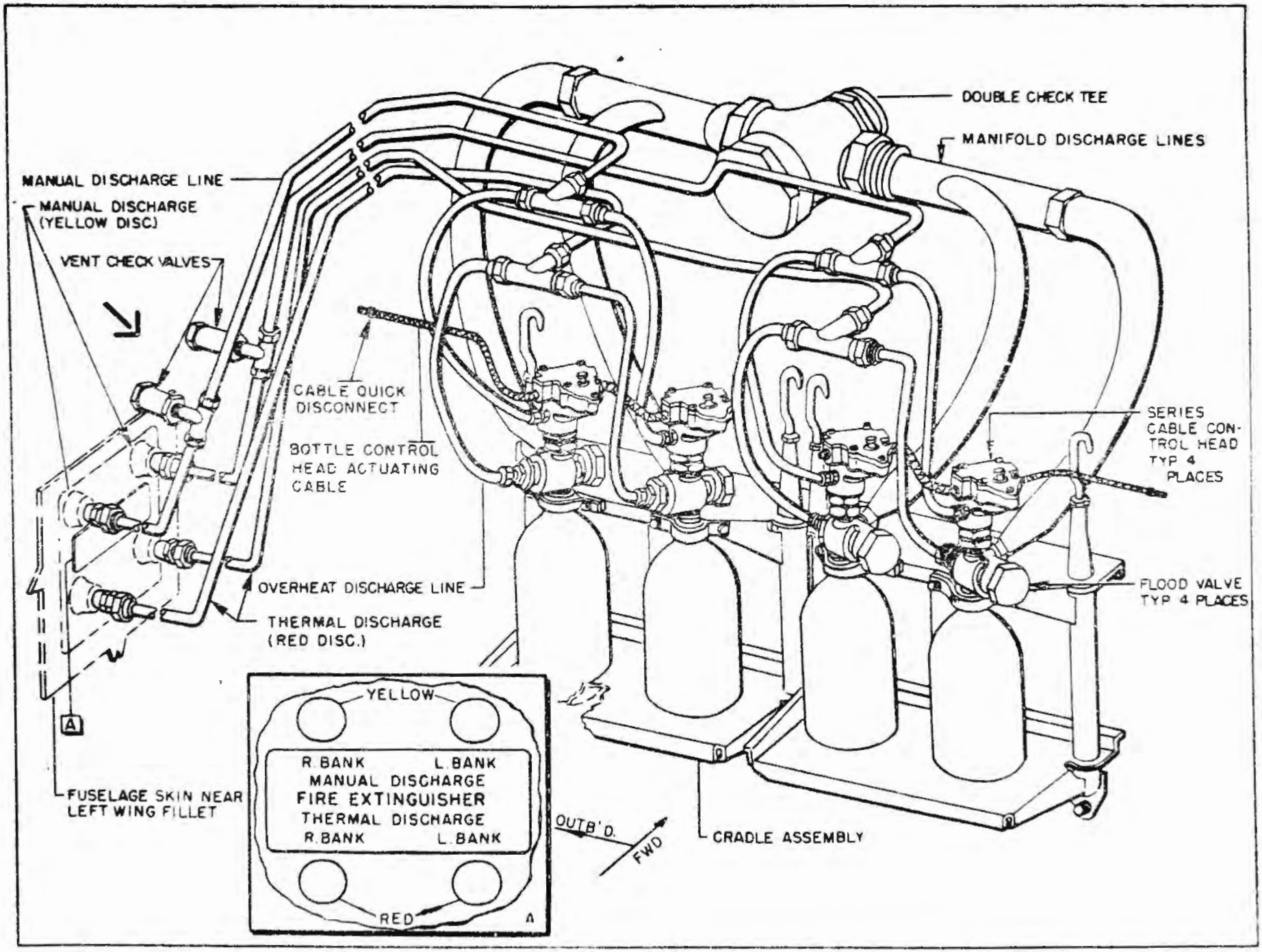


Figure 15. Carbon Dioxide Bottles, Flood Valves, And Plumbing Installed

Oxygen System - General (See Figure 3)

A high pressure continuous flow oxygen system is provided for all crew members and passengers. The system consists of two oxygen cylinders, pressure regulator and gauges, relief valve, passenger shut-off valve, overboard discharge indicator, oxygen masks, outlets for crew members and passengers and an emergency walk-around oxygen kit.

The oxygen cylinders are installed on the right hand side of the airplane above the radio rack. Each cylinder is an 853 cubic inch cylinder with a pressure of 1800 psi when fully charged. Each cylinder is equipped with a shut-off valve and a safety discharge port. Later type valves also incorporate an integral pressure gauge which indicates cylinder pressure.

The pressure regulator is located on the forward right hand side of station 212 just aft of and above the co-pilots seat. The entire supply system pressure is controlled by this regulator. The regulator consists of a manual regulator valve, a high pressure gauge and a low pressure gauge. The pressure regulator reduces the oxygen cylinder pressure to 30 psi or less and maintains a constant flow of oxygen regardless of cylinder pressure, temperature or airplane vibration. The regulator is set so that the flow gauge indication corresponds to the pressure setting specified for the existing cabin altitude. The cylinder pressure gauge is calibrated from 0 to 3000 psi. The flow gauge is calibrated from 0 to 30 psi. This assembly normally requires no service between overhaul periods; however, if it malfunctions or leaks during service, replace as an assembly.

Overboard Discharge Indicator (See Figure 1)

A discharge indicator with a green disc is installed in the fuselage at station 281, approximately 3" above the floor right hand side. A high pressure line from the neck of the oxygen cylinder connects to this indicator and will vent the oxygen overboard if the frangible disc in the oxygen cylinder valve should rupture from excessive pressure. The green disc will blow out indicating that the cylinder has discharged. Such discharge necessitates replacing the oxygen cylinder with one fully charged and installing another green disc. The green disc can be replaced from the outside of the airplane by removing the snap ring and installing a new disc.

Passenger Shut-Off Valve (See Figure 3)

The passenger shut-off valve is installed in the oxygen system above and inboard of the pressure regulator and is accessible to the co-pilot. The valve permits the crew to shut off the oxygen supply to the passengers, observer and hostesses' outlets. The valve should be kept closed, this will prevent leakage at the valve stem. This unit normally requires no service between overhaul periods, however, if it malfunctions or leaks it must be replaced. Do not attempt to adjust it.

Oxygen Outlets (See Figure 3)

The supplemental oxygen outlets for the pilot and co-pilot are located in the cockpit crown outboard and aft of the respective positions. The forward hostess outlet is located in the door coaming aft of station 212 left hand side. The outlet for the observer is located in the door coaming forward of station 212 right hand side. The aft hostess outlet is located above her seat in the ceiling of the carry-on baggage rack. The outlet in the lavatory is located inboard and forward of the door and is adjacent to the hostess call button. The passenger outlets are located on the reading light panels directly above each seat. These outlets are all supplementary (normal) breathing type with an (.018") orifice and are standard bayonet type fittings that shut off automatically when the bayonet fitting of the oxygen mask is uncoupled and a spring loaded cover closes the opening.

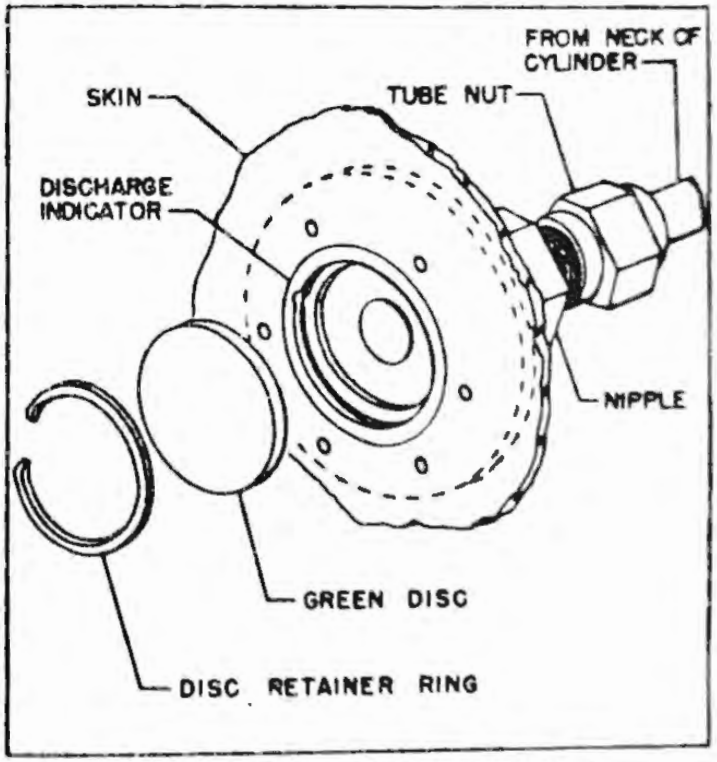


Figure 1. Oxygen Overboard Discharge Indicator

Supplementary Oxygen Masks

There are (9) supplementary oxygen masks stowed on the airplane for use by the crew and passengers. See Series 4-1 for mask stowage locations.

For information regarding packing and servicing of masks, refer to Maintenance Notes under "Oxygen Masks (Supplementary and Protective".)

Protective Oxygen Masks

There are (2) protective oxygen masks, permanently connected to the individual shut-off valves, for the use of pilot and co-pilot.

These are full face masks and are to be used only in the case of an emergency, such as dense smoke or high CO_2 concentration.

Emergency Walk-Around Oxygen Kit

An emergency walk-around oxygen kit consisting of a low pressure oxygen cylinder with a demand type regulator, asbestos gloves and a demand type oxygen mask is located above the snack cabinet on the forward side of the galley bulkhead. This kit is provided so that in emergencies, crew members may enter smoke filled or high CO_2 concentrated areas. The duration of the cylinder is approximately 12 to 15 minutes and the user should prepare to leave the danger area when cylinder pressure drops to 100 psi. The low pressure cylinder should be serviced to 425-450 psi which provides approximately 5.9 cubic feet of breathing oxygen. Replace cylinders having less than 425 psi at 70° as indicated by the pressure gauge.

OXYGEN SYSTEM INSTRUCTIONS

Caution Protective Oxygen Shut-Off Valves Must Be Off Except When Using Smoke Masks.

Before Take Off	To Use Smoke Masks
1. Open supply cylinder valves slowly.	1. Open individual shut off valves.
2. Turn regulator slowly clockwise - set at 15 psi.	2. Adjust regulator to maintain 6 psi.
To Use Supplemental System	**To Shut Off System**
1. Plug in masks.	1. Close regulator.
2. Adjust regulator to required pressure.	2. Close cylinder valves.
3. Open cabin shut off valve.	

Supplemental Requirements

Altitude	Regulator Setting	Always Open and Close all Valves Slowly
10,000	2.0 psi	
12,000	3.2 psi	
14,000	4.4 psi	
16,000	5.5 psi	
18,000	6.6 psi	

For Medical Requirements Set at 30 PSI

Figure 3. Oxygen System Installation

INSTRUMENTS - GENERAL.

The conventional pressure, temperature, flow, position and quantity instruments provided for on the airplane are covered in this chapter under the typical indicating systems such as: Magnesyn, Autosyn, Selsyn, temperature and quantity indicating systems. The individual indicators and transmitters of each particular system are described in detail in their respective chapters. The flight instruments are covered under the pitot-static system, the gyro stabilized navigation system, and the standby magnetic compass.

The purpose of these typical indicating systems is to provide a reference to the description and operation of a particular system whose function is identical to that of the typical system.

PILOTS' INSTRUMENT PANEL (See figure 10).

The pilots' instrument panel assembly is installed as a single unit extending across the pilot's compartment forward of the control column. It is divided into three removable individual panels, the pilot's flight instrument panel, the engine instrument panel, and the co-pilot's flight instrument panel. The instrument panel assembly is attached by six conventional bolted shock mounts to prevent the transmission of excessive vibration to the instruments. Flight instruments are mounted on the removable panels directly in front of the pilot and co-pilot. The engine instruments are mounted on the center removable panel. Other instruments are mounted on the non-removable sections of the instrument panel assembly.

Each instrument is individually back-mounted and can be readily serviced or replaced. The electrically-operated instruments are wired individually from the rear of the instrument panel. The air operated instruments are connected by flexible hoses. Hoses of different sizes are used where more than one connect to the same instrument.

The instrument panel is lighted with red lights installed in the glare shield recess for daylight and night operation. These are supplemented with high candle power white lights for "on top" operation in daylight and in other periods of very high outside light intensity.

STANDBY MAGNETIC COMPASS (See figure 1).

The standby compass is installed aft of the windshield on the airplane centerline. It is a direct indicating magnetic compass of the floating card type which will show the heading of the airplane with respect to magnetic north, by means of a graduated card read against a fixed line called a lubber line. The compass is usediin conjunction with the fluxgate compass system in the event of power failure. The compass will operate satisfactorily at temperatures from - 35°C to +40°C. The damping fluid in which the card floats is a refined fraction of crude petroleum, free from moisture, acidity, glue, and other impurities. The function of this fluid is to prevent the card assembly from moving too freely. It there were none, the assembly would move continuously. A compensating mechanism is attached to the compass to provide a means of compensating for deviation. The unit contains two sets of permanent bar magnets arranged in two different planes and at right angles to each other. Each set is adjusted by means of a slotted head, one marked N-S, and the other E-W, located under the shutter of the front cover, refer to "Magnetic Compass Swing Procedure" for instructions. The compass will normally not require servicing between overhaul periods; however, if it malfunctions it should be replaced and the new compass swung and compensated.

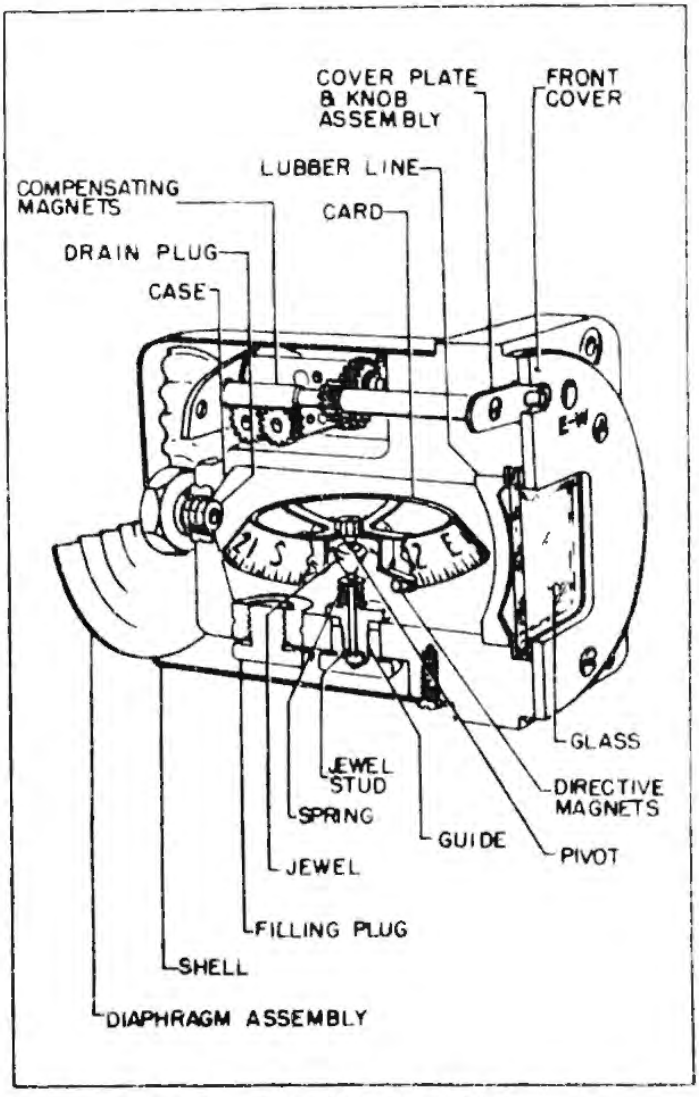


Figure 1. Standby Magnetic Compass.

PITOT - STATIC SYSTEM - GENERAL (See figure 12).

The pitot static system is used to furnish accurate values of impact (pitot) and static pressures during motion of the aircraft through surrounding air. Specifically, the system supplies impact pressure to the sensitive elements of the airspeed indicators and static pressure to the cases of the airspeed indicators, altimeters and rate of climb indicators. The source of these pressures consists of two pitot heads, two flush static plates and two alternate static fittings.

Pitot - Static System Operation (See figure 2).

The left pitot head supplies pitot pressure to the pilot's airspeed indicator, and the right pitot head supplies pressure to the co-pilot's airspeed indicator. Normal static pressure is supplied from the flush static plates which are mounted on each side of the fuselage at station 130. Each plate contains two air vent holes. The forward hole on the left flush static plate and the forward hole on the right flush static plate are interconnected and supply static pressure to the Captain's static selector valve. The aft hole on the left flush static plate and the aft hole on the right static plate are interconnected and supply static pressure to the First Officer's static selector valve. Two toggle operated static selector valves, one on the pilot's and one on the co-pilot's instrument panel provide a means of selecting either "Normal" static source from the static plates, or "Alternate" static source from fittings located in the nose well forward of station 142. Operation of the above indicators depends on differential pressures within the case and bellows of each indicator; therefore, all fittings and indicator cases must be air-tight to obtain accurate indications under all conditions of flight. Refer to "Pitot System Functional Test" and "Static System Functional Test" for these indicators.

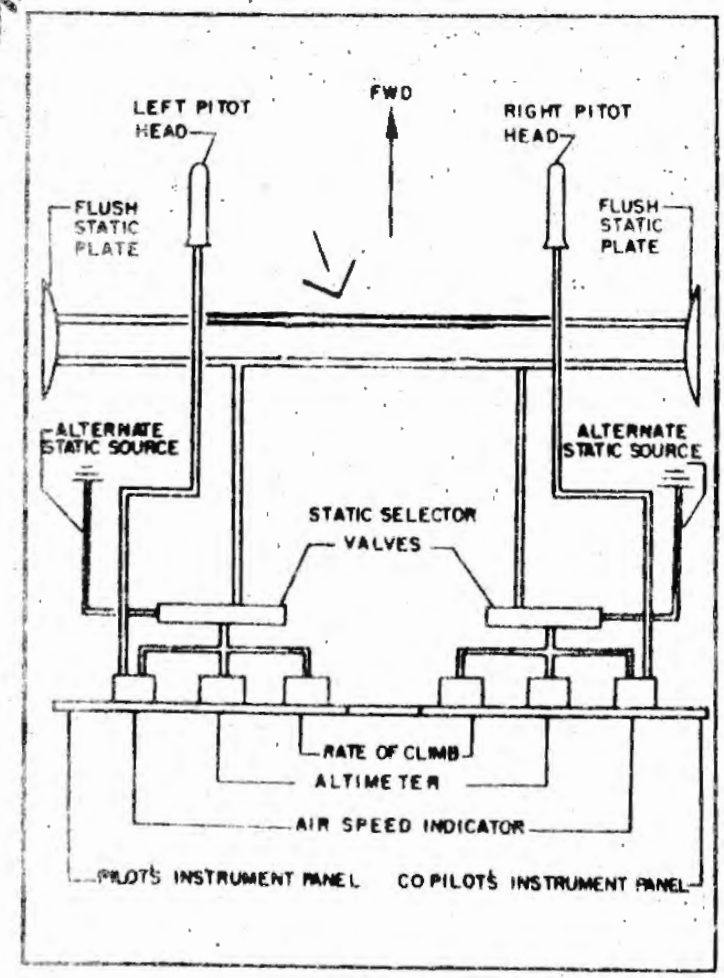


Figure 2. Pitot-Static System Schematic

PITOT-STATIC SYSTEM COMPONENTS.

The pitot-static system consists of pitot heads, flush static plates, static selector valves, airspeed indicators, rate of climb indicators and altimeters.

Pitot Heads (See figure 3).

Two electrically heated pitot heads are mounted horizontally on the nose of the fuselage, refer to Chapter 18 for heater details and functional test. The pitot heads are used to supply dynamic air-pressure to the pilots and co-pilots airspeed indicators. Each tube contains a hermetically sealed heating element to prevent the formation of ice on the tube in severe icing conditions. Rain is prevented from entering the tube, either in the air or on the ground, by a baffle located just inside the front opening. Any water that may get into the head from ice formed on the head, before the heating element is operating is caught by water traps in the head, and expelled through drain holes in the bottom of the head. The pitot heads shall be polished during service with a mild silverware polish (not aluminum polish) and the drain holes cleaned to assure that accurate values of pitot pressures are

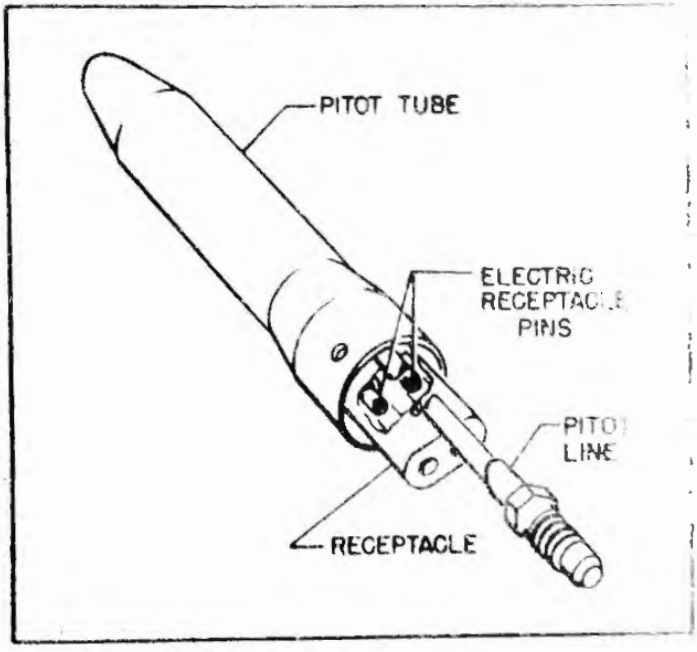


Figure 3. Pitot Head

Pitot Heads (Cont.).

obtained at all times. If the head is damaged or the heater element malfunctions replace the head refer to "Pitot Head Replacement" for procedure.

Static Selector Valve (See figure 12).

Two static selector valves are located on the main instrument panel, one each on the pilot's and co-pilot's instrument panel. Each valve is a toggle type snap-action control valve which permits the pilot or co-pilot to select static air pressure from either the flush static plates or the alternate static source. It has two "on" positions, "NORMAL SOURCE" and "ALTERNATE SOURCE", and no "off" position. The center port to which the flight instruments are connected is always open and the air flows from either of the two end ports through the center port.

Flush Static Plates (See figure 12).

A flush static plate is installed on each side of the fuselage at station 132. The plates provide the static source of air pressure for the static system. Each plate contains two air vent holes, and two mounting studs. The left hand forward and the right hand forward vent holes are interconnected and supply static pressure to the Captain's instruments. The left hand rear and the right hand rear vent holes are interconnected and supply static pressure to the First Officer's instruments. Each plate is attached to the fuselage by the two studs. Care shall be taken to keep the vent holes open at all times.

Airspeed Indicator (See figure 10).

Two conventional airspeed indicators are provided, one each for the pilot and co-pilot. They are mounted on the instrument panel directly in front of the respective position, and are operated by pitot pressure supplied from the pitot heads in the pitot static system. The airspeed indicator is a sensitive, differential pressure gage which measures the difference between the static pressure of the air through which the airplane is flying, and the impact pressure created by the forward speed of the airplane. Impact pressure is exerted on the inside of the diaphragm of the indicator from the pitot head, and static pressure is exerted on the outside of the diaphragm from the flush static plates. The difference between these pressures exerted on the diaphragm shows the indicated airspeed of the plane.

Altimeters (See figure 10).

Two conventional sensitive altimeters are provided, one for the pilot and one for the co-pilot, located on the respective instrument panels. They are operated by air pressure supplied through the static system to indicate the height of the airplane above some reference point (generally mean sea level).

The altimeter measures the ex[illegible] barometric pressure and since atmospheric [illegible] sure varies with altitude, this pressu[illegible] indicated on the dial in feet of alti[illegible] Three concentrically arranged hands ind[illegible] in feet of altitude on a common scale. [illegible]arge hand which indicates hundreds of [illegible] moves once around the dial for each 1,0[illegible] of altitude. The intermediate hand, [illegible] indicates thousands of feet, moves once [illegible] the dial for each 10,000 feet of altitude [illegible] third hand, which indicates 10,000's of [illegible] moves only 35 revolutions for the instr[illegible] range of 35,000 feet. A barometric [illegible] visible through the window in the a[illegible] dial, indicates barometric pressure in [illegible] of mercury. The range of the scale [illegible] 28.1 to 31.0 inches of mercury. An adjus[illegible] knob, located on the lower left corner [illegible] case, provides a means of adjusting the [illegible] and barometric scale simultaneously to com[illegible] for changes in atmospheric pressure resul[illegible] from changing weather conditions.

Rate of Climb Indicator (See figure 10).

Two conventional rate of climb indicators [illegible] provided, one each for the pilot and co-pi[illegible] They are mounted on the instrument panel [illegible] ectly in front of the respective position[illegible] are operated by static air pressure supp[illegible] through the pitot-static system. The rate [illegible] climb indicator is used on the airplane [illegible] indicate the vertical component of the a[illegible] planes speed, based on the rate of change [illegible] atmospheric pressure. This is indicated [illegible] the dial as rate of ascent or rate of des[illegible] in feet per minute. A single hand indica[illegible] the rate of ascent or rate of descent in hu[illegible] dreds of feet per minute. The normal p[illegible] tion of the hand when at zero is horizon[illegible] pointing left. From this position, it mo[illegible] clockwise when indicating ascent and coun[illegible] clockwise when indicating descent.

Magnesyn Type Indicating Systems - General.

Nine systems on the airplane utilize magnesyn units to transmit and indicate the following manifold pressure, oil pressure, fuel pressure, hydraulic pressure, emergency brake pressure, water pressure, fuel flow, oil quantity and wing flap position. A magnesyn system is essentially a means of remote indication, electrically of a given function. The system consists, basically, of a transmitter located at or near the function to be measured and an indicator mounted on the instrument panel. The individual indicators and transmitters are covered in their respective chapters, refer to the index of the particular chapter for description.

The pilot's and co-pilot's flight and engine instrument panels can be removed for servicing or replacing the instruments by loosening the screws in the panel retaining strips and remove the strips; this permits the individual panel to be pulled aft. Access to the rear of the instrument panel may also be gained by entering the nose wheel well and removing the pressure door in the top of bulkhead 142.

Principle Of Operation (See figure 4).

The magnesyn system is basically composed of two magnesyn units connected in parallel. The magnesyn unit consists of a permanent magnet moving within a stator, consisting of a core of magnetic material wrapped with a single winding. The stator winding is divided into three sections by means of the signal and power taps. Voltages in each section vary with the position of the permanent magnet. When the magnesyn transmitter and indicator are connected in parallel and excited by the same fundamental source, the signal voltages in corresponding sections of the two stators are equal and balanced as long as the magnets are in the same relative positions. Movement of the transmitter magnet to a new position creates an unbalance of the voltages between the two stator windings causing current to flow between the two magnesyns. The circulating current created a magnetic force between the stator and magnet of each unit, and since the magnet in the indicator is free to turn, it will move to a position corresponding to the position of the magnet in the transmitter.

Magnesyn Indicators - General.

Basically, the magnesyn indicator consists of a magnesyn, a graduated dial and a pointer. The magnesyn consists of a permanent magnet moving within a stator, this movement causes the pointer to rotate and indicate on the dial the valve received from its respective transmitter. Indicators for various systems differ essentially only in the type of dials used. A dual indicator consists of two individual magnesyns mounted one behind the other in the same case, and each operates an individual pointer of the indicator. Each magnesyn is electrically connected to the magnesyn of a transmitter, thus the electrical impulses from two transmitters are registered on the one dial of the dual indicator. The pointer placement may be "concentric" or "side-by-side" depending on the type of the dual indicator. In concentric placement, the pointers operate from a common center of the dial, each pointer using the same dial markings. In side-by-side placement, the pointers operate on a common line from opposite sides of the center of the dial, each pointer using separate dial markings. Pointer shapes vary, and the pointers of the dual concentric indicator may be marked "L" "R" or "1" and "2".

Magnesyn Transmitters - General.

A magnesyn transmitter is composed of two main parts, an instrument mechanism, and a magnesyn unit. Characteristics of the various transmitters are essentially the same, differing in the type mechanism used. The mechanism may be a bourdon tube, bellows assembly, vane float or gear drive type depending, on the function to be measured. Each mechanism also has a linkage for converting the action of the measuring device into rotary motion. The linkage is connected to the permanent magnet, which is basically the same for all transmitters regardless of function. The magnesyn unit used in all transmitters and indicators are similar in construction and identical in elec-

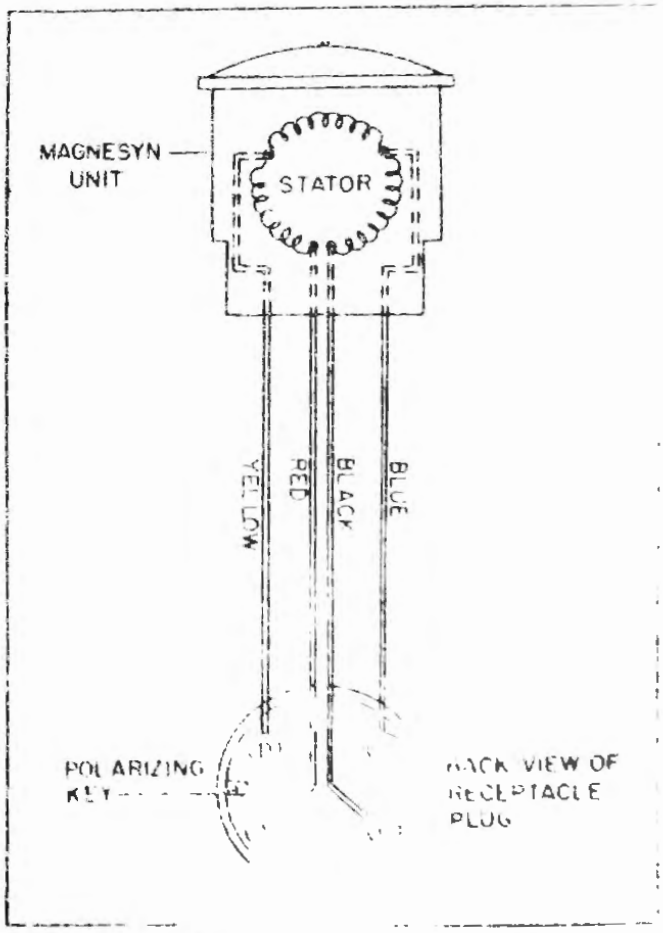


Figure 4 Magnesyn Transmission Schematic

Magnesyn Transmitters - General (Cont.)

trical characteristics. Each consists of a permanent magnet moving within a stator, and electrically connected to the magnesyn of its respective indicator.

Magnesyn Transmitters Using Bourdon Tube Mechanism.

The emergency brake and hydraulic pressure transmitters use the bourdon tube mechanism. Operating pressure enters through a pressure fitting which is connected directly to the bourdon tube. The other end of the tube is free to move and is connected to a sector gear by linkage. The sector gear engages a pinion gear which in turn is secured to the end of the magnet shaft assembly. The operation and function of all the bourdon tube type transmitters is the same; however, the transmitters are not necessarily interchangeable. Set screws are mounted on the bourdon frame to limit the over-pressure expansion of the bourbon tube, thus permitting proper calibration of the transmitter and limiting its use to one system.

Magnesyn Transmitters Using Bellows Mechanism.

The fuel, oil, water and manifold pressure transmitters use the bellows measuring device to engage the instrument mechanism for position- of the magnesyn magnet. Pressure on the inside of the bellows causes it to expand. This movement is transmitted to the magnet of the transmitting magnesyn.

Magnesyn Transmitters Using A Float-Type Mechanism.

The oil quantity transmitter uses the float-type measuring device to engage the instrument mechanism for positioning of the magnet of the transmitting magnesyn. Movement of the float assembly is transferred to the permanent magnet of the magnesyn assembly by action of bevel gears.

Magnesyn Transmitters Using Vane-Type Mechanism.

The fuel flow transmitter uses the vane-type measuring device to actuate its instrument mechanism for positioning of the permanent magnet of the transmitting magnesyn. The vane or "actuating element" is pivoted and mounted in a spirally-cut fuel chamber which has an inlet and outlet port to permit fuel to flow through the chamber. The movement of the vane is restrained by a calibrated spring. Gasoline passing to the engine enters the inlet port and is directed against the vane. Impact of the fuel causes the vane to swing like a gate in the spiral chamber. The force of the calibrated spring opposes this movement and when these two forces balance, the vane stops moving. The final position assumed by the vane represents a measure of the rate at which the fuel is passing through the metering chamber. The permanent magnet is attached to the shaft and actuated by movement of the vane. An integral spring-loaded relief valve provides an internal by-pass which permits some fuel to flow from the inlet to the outlet port without passing through the fuel chamber if the rate of flow exceeds the capacity of the instrument.

TOLERANCES FOR INSTRUMENTS (CONT.)

Alcohol Fluid Level Indicating System

At installation and at readjustment, adjust until pointer is exactly at "E" and "F", with transmitter float in the corresponding empty and full positions. Allow ± 1 gal. error at these positions during service.

FUEL FLOW

See Chapter 12.

Tachometer Indicating Systems (Engine)

SPEED (RPM)	MAXIMUM TOLERANCE
500 to 800	± 40 RPM
800 to 1000.	± 35
1000 to 1200	± 30
1200 to 1500	± 25
1500 to 1800	± 20
1800 to 2600	± 15
2600 to 3000	± 20
Pointer oscillation shall not exceed.	20
*Friction error shall not be in excess of	20

Magnetic Compass (Stand By) - Ground Check

CONDITION	MAXIMUM TOLERANCE
Maximum error	± 5° (After Compensation)

Compass should be replaced if bubble exceeds 7/8 inch wide with compass in level operating condition or 5/8 inch diameter when face is turned up.

Gyro Horizon (Electric)

"0" position of bank index 1/64 inch
"0" position of bar . . . 1/32 inch

Tolerances applicable only if plane is level laterally and longitudinally.

Warning Light, Engine Fuel Pressure

See Chapter 12.

Warning Light Engine Oil Pressure

See Chapter 13.

Functional Test of Static System

SPECIAL TOOLS: Masking tape, placard, a pitot static system test kit and a short length of rigid tubing with "BT" nut and sleeve for connecting to alternate static ... well bulkhead fittings.

NOTE: While testing static systems, masking tape shall be used to cover the static ... Tape shall be of sufficient length to properly seal the opening and allow an additional length remaining to be doubled and stuck together forming a streamer to hang from the fuselage vents. In addition, a wooden placard stating that the "STATIC OPENINGS ARE COVERED, DO NOT DISPATCH A/C UNTIL REMOVED", shall be attached to the throttles and shall not be removed until the masking tape is removed.

Procedure	Special Instructions
1. Note pointer indication of altimeter of system to be checked.	1. If desired, rotate pointers to zero ... lightly tap altimeter to remove fric...
2. Connect special test fitting to the respective alternate static bulkhead fitting in nose wheel well. Connect test equipment to fitting.	2. Bulkhead fittings are located on bulkhead forward of instrument panel. Connect to the left bulkhead fitting when checking Captain's system or right fitting for checking First Officer's system.
3. Place static selector valve, of system being checked, in the "ALTERNATE" position.	3. Captain's and First Officer's static selector valves are located on their respective instrument panel.
4. Apply pressure to system until 60 to 100 MPH or 50 to 85 knots is indicated on test indicator; then pinch off tubing to trap air in system and test indicator.	4. Do not exceed specified pressure as it may damage the delicate parts of the instrument. Indication on test indicator may drop slightly and then stabilize if there are leaks in the system.
5. When pressure is applied to the static system, note that the climb indicator of the system being checked indicates descent ("DOWN") and slowly returns to "0". At the same time the altimeter should indicate 200 to 250 feet lower than noted in Step 1 preceding and hold at that point provided that there are no leaks in the system.	5. If the climb and altimeter indicator point do not stabilize and hold, the static system leaks.
6. Note pointer indication of altimeter of system to be checked. Observe reading again after 1 minute.	6. Maximum allowable leakage is 10 feet in minute.
7. Seal one fuselage static vent on each side of nose structure.	7. Seal the forward hole of each fuselage static vent plate when checking Captain's system. Seal the aft hole of each fuselage static vent plate when checking First Officer's system.
8. Apply pressure to test equipment on alternate static fitting and at the same time operate the static valve, on the system being checked from "ALTERNATE" to "NORMAL" position a few times until no movement of the indicator pointers is noted as valve is operated from one position to the other. Pinch off tubing to trap air in static system and test equipment.	8. Positioning of the selector valve will vary the pressure applied to the instruments and the system lines. If the system is tight (no leaks) it is possible to equalize the pressure in both static systems, thus providing a means of checking both static systems from the same point. It will be necessary to replenish the pressure applied to the alternate static system as it is expelled into the normal static system until the pressure has equalized. Apply pressure equivalent to 60 to 100 MPH or 50 to 85 knots as indicated on test airspeed indicator.
9. Place the static selector valve in the "NORMAL" position.	

Procedure (Cont.)	Special Instructions
Remove test equipment tubing to release pressure trapped in alternate system and note action of static instruments, on system being checked for 1 minute.	10. Maximum allowable leakage is 10 feet in 1 minute.
Remove masking tape from one of the fuselage static vents sealed in Step 6 and note action of the static instruments. Remove test equipment including masking tape and placard on throttles. Determine that both static vents on each side of nose structure are open and free of any obstruction.	11. In system being checked the climb indicator should indicate ascent ("UP") and slowly return to "0". Altimeter pointer should return to the position noted in Step 1 preceding.

Functional Test of Pitot System

When testing pitot system, masking tape shall be used to cover the pitot head drain openings. Tape must be of sufficient length to properly seal the opening and allow an additional length remaining to be doubled and stuck together, forming a streamer to hang from the pitot head. This is done to eliminate the possibility of the tape remaining on the vents unnoticed after the test has been completed.

Procedure	Special Instructions
Install pitot head adapter with test airspeed indicator attached on the left pitot head covering impact hole on forward end of head.	1. Use special pitot head adapter.
Seal drain hole in pitot head.	2. Use masking tape as per previous instructions
Apply pressure to test adapter until test indicator reads 450 MPH or 280 knots. Pinch tube to trap pressure in test indicator and pitot system to the Pilot's airspeed indicator. Indication should hold if system is not leaking. If indication does not hold, locate and correct leakage before preceding with test.	3. Apply pressure slowly and evenly so as not to damage the delicate mechanisms of the airspeed indicators.
Start test at 450 MPH 280 knots on the test airspeed indicator, then allow pressures to leak out of system in 50 MPH or 40 knots decrements and check accuracy of Pilot's airspeed indicator.	4. Tap instrument with finger-tip to remove pointer friction while conducting test. Replace airspeed indicator if it is not within tolerances.

Range	Tolerance
Pointer at 40 knots	± 3/64 inch
40 to 59	± 2 knots
60 to 89	± 2
90 to 169	± 3
170 to end of scale	± 4
Case leak with pressure on static equivalent to 60 knots.	0 in one minute
Friction not in excess of	2 knots

Remove masking tape and test equipment from left pitot head; then reinstall equipment or adapt pitot head as per Step 1, and seal opening.	
Repeat steps 3 and 4 preceding and check accuracy of the Co-Pilot's airspeed indicator.	6. See Special Instructions, Step 4. preceding
Remove masking tape and test equipment from right pitot head.	

GENERAL.

The power plant is a complete, self-contained power package, referred to as a "quick change unit", which provides a fast, efficient method of changing engines on the airplane. The components consist of the engine, engine build-up accessories, engine mount and dynafocal mounts, baffles, shroud, hood and accessory cowling, cowl flaps and the induction, ignition, water injection, exhaust and indicating systems. The propeller might be considered a part of power plant, but it is covered in Chapter 10. In the same token, the oil system is covered in Chapter 13. The quick change unit, with the exception of the cabin supercharger compressor and its associated units, is interchangeable from right to left and between airplanes.

ENGINE.

The airplane is powered by two Pratt and Whitney Double Wasp - CB-16 supercharged, 18 cylinder, twin-row, radial air-cooled engines, each of which has a total piston displacement of 2804 cubic inches. The engines are equipped with pressure injection carburetors, automatic valve oiling, radio shielding, torque noses, water injection, priming system, and a low tension ignition system.

Engine Mount And Dynafocal Mounts (See figure 1).

The engine mount is of conventional design, being constructed of heat treated steel tubing and gussets. It attaches to the firewall with three thru-bolts torqued to 4000-5000 in.-lbs. on the upper bolt and 2000-2400 in.-lbs. on each of the two lower bolts. The mount spacer pad fittings are attached to the firewall by a flange with four bolts thru the firewall. See figure 12 - Series 11-2.

The forward end of mount has provisions for attaching six dynafocal mounts which are secured to the engine supercharger section and normally require no servicing between overhaul periods.

COWLING - GENERAL (See figure 13).

The cowling provides a streamline fairing around the engine and accessory compartment and is an essential agent in cooling the engine. The cowling is removable and interchangeable between airplanes. Hood cowling and accessory cowling may be removed independently of each other.

Engine Hood Cowl And Front Support Ring (See figure 2).

The engine hood cowl is composed of three sections: the top panel forming an arc of 110° and the two lower panels of 125° each. The engine hood cowl is supported by two rings. The hood rings each have a locating hole which receives the locating pins installed on the top engine hood panel. The locating pins permit quick and definite location of the parts and prevent the cowling from rotating around the engine. The front ring assembly is attached to the ring mounting bosses on the engine at nine locations by mount assemblies. Each mount assembly consists of a beryllium copper spring plate molded in a synthetic rubber mount and is inclosed by and bonded to an aluminum alloy case which is bolted to the hood ring. The mount assembly insulates the hood ring and the engine hood cowl from the vibration

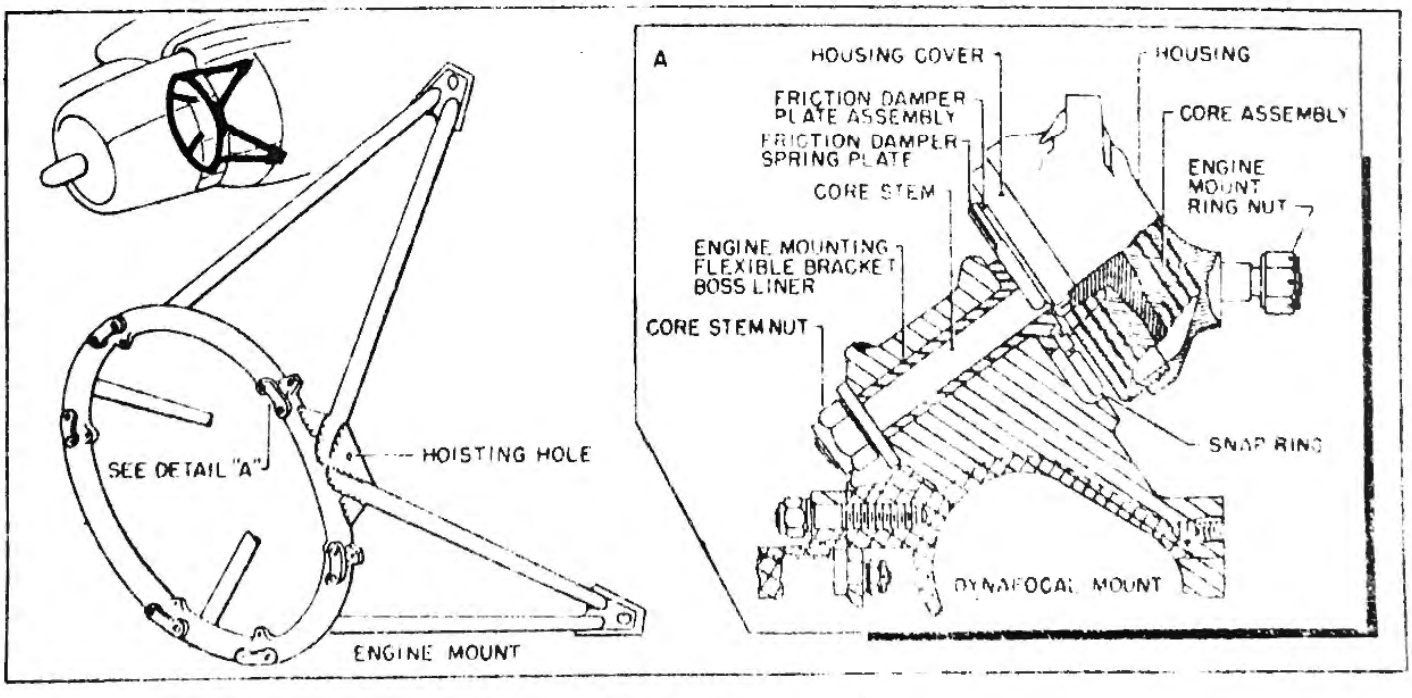


Figure 1. Engine And Dynafocal Mounts.

Engine Hood Cowl And Front Support Ring (Cont.).

of the engine. Molded synthetic rubber chafing strips are attached to the rings by small buttons which are inserted through holes in the support rings. These strips reduce wear of the mating surfaces and are replaceable. The right and left hood panels are assembled to the top hood panel by joining the interlocking claw strips on the edges of the panels at the split line and securing with the integral spring fasteners. The right and left panels are joined together at the bottom by three adjustable self locking latches. When in the closed position, these latches shrink the three panels about the supporting rings, thus fixing the panels in position. A close fitting gap strip covers this bottom split line and is attached to the left panel with spring fasteners. The front support ring and the hood cowling is interchangeable between right and left engines and between airplanes. Whenever a section of the engine hood cowl requires replacing, the entire hood cowling should be replaced and not just one section. The hood cowling is repaired and matched as an assembly thereby facilitating easier installation on the airplane.

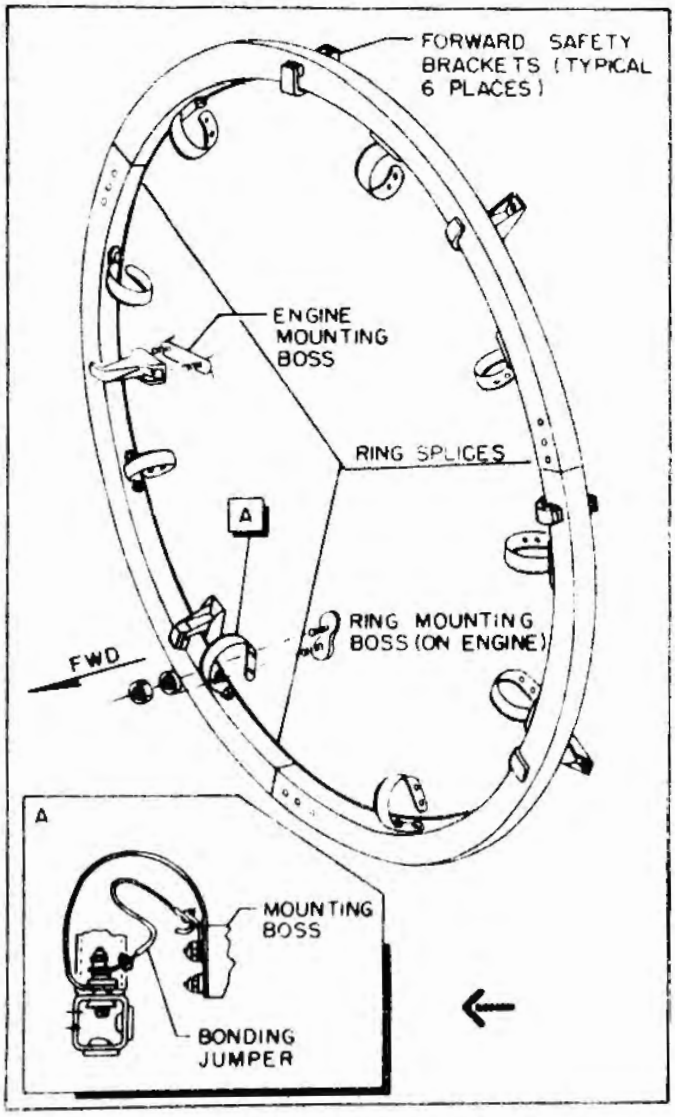


Figure 2. Front Hood Cowl Support Ring

Accessory Cowling.

The accessory cowl, extending from the outer flange of the power plant shroud assembly to the firewall, and enclosing the engine accessory section of the power plant, consists of a left and right top panel, a left and right side panel and a lower left panel. On the left side of the engine between the upper and lower panels is a trough partially enclosing the exhaust tail pipe. The trough on the right side of the engine is an integral part of the housing around the oil cooler. A cover attaches to the trough on each side to form a complete housing about the tail pipe. The lower right hand section of the accessory cowl incorporates the oil cooler duct and is also a housing for the cooler. This section will not be taken down except when changing an oil cooler.

The accessory cowl panels are fabricated from formed corrosion resistant sheet steel to which are spotwelded pressed corrosion resistant steel reinforcements. Each panel is interchangeable between the left and right power plant installations. The two top accessory cowl panels also serve as fairing for the carburetor air scoop. The right and left side accessory panels each include a door to permit quick access for the insertion of a fire extinguisher nozzle. The five panels, the exhaust stack covers, and the trough are attached with spring fasteners around the edge of the exhaust collector shroud assembly and the nacelle.

Each piece of cowling can be removed independently of the other pieces and is interchangeable between right and left engines with the exception that the top inboard piece on the right engine has an additional access door to facilitate servicing the cabin supercharger compressor oil tank.

COWL FLAPS - GENERAL.

Each engine is equipped with a seat of six cowl flaps, five of which are moveable and one stationary. These flaps are located at the aft end of the engine hood cowling and provides a variable throat for the passage of engine cooling air between the hood cowling and the accessory cowling. To increase the flow of air, the cowl flaps are extended radially outward from the center line of the engine. To decrease the flow of air, they are closed toward the accessory cowl.

The flaps are attached to the cowl ring with a strip of rubber impregnated cloth known as fabreeka, which acts as a hinge for each flap. The hinge assembly is bolted to the ring and flap.

The cowl flaps are operated by electrically actuated jack screw assemblies. In the normal, or 0 degree position, the distance between the trailing edge of the cowl flap and the accessory cowl is 2 inches. The closed position of the cowl is 1 inch from the accessory cowl, or 6.5 degrees closed from the normal position. Maximum cowl flap opening is 7½ inches from the accessory cowl, or 30 degrees outside the normal position. All degree readings are cockpit indicator readings.

Cowl Flap Operating Mechanism (Cont.).

the rotating disc. This action stops the motor and holds it until power is again applied for reverse direction. The limit switches are adjustable and determine the extremes of travel for the linear jacks in their retracted or extended position. The nut assembly riding on the proportional screw in the switch box, also operates the movable arm of the potentiometer which controls the operation of the respective flap position indicator in the center instrument panel.

Cowl Flap Actuator Circuit (See figure 4A).

The power for the cowl flap circuit is supplied from the 28 volt d-c forward distribution bus to the "L.H. COWL FLAP ACTUATOR" circuit breaker and the "R.H. COWL FLAP ACTUATOR" circuit breaker located on the main circuit breaker panel. From the L.H. circuit breaker the power travels to the "LEFT COWL FLAP" control switch located on the overhead switch panel. This is a three-position switch, "OFF" being in center position. Momentary "CLOSE" position is down and the "OPEN" position is up. Power from the control switch then travels to the left engine cowl flap actuator and transmitter passing through the radio noise filter. The circuit from the "R.H. COWL FLAP ACTUATOR" circuit breaker to the "R.H. COWL FLAP" control switch also located on the overhead switch panel and to the right engine and flap actuator and transmitter is the same.

Cowl Flap Indicator Circuit (See figure 4A).

The cowl flap indicator circuit provides a means of indication to the pilots as to the position of the cowl flaps on either engine.

The circuit consists of a dual-reading indicator located on the engine instrument panel and a transmitter attached to each cowl flap actuator assembly located in the engine accessory section.

Power for the cowl flap indicator circuit is supplied from the 28 volt d-c forward distribution bus through the "COWL FLAP IND." circuit breaker located on the main circuit breaker panel. For further information refer to the Electrical Wiring Data Book.

ENGINE SUPERCHARGER CONTROL

The single stage blower of each engine has a two speed control. The blower control unit for each has an external valve which is solenoid actuated with the aid of the oil pressure. The solenoid is controlled by a cockpit switch mounted on the Pilot's overhead electrical panel. The solenoid operates a small oil valve which in turn controls a larger valve that actuates the blower clutch mechanism from "LOW" to "HIGH" position. The solenoid and control valve are spring-loaded. In the event of electrical power failure to the coil the engine supercharger will return to or remain in the "LOW" speed position. Each blower selector solenoid is protected with a 5 ampere circuit breaker located on the main circuit breaker panel.

No field adjustments are possible on this unit. Malfunction is cause for replacement.

ENGINE ACCESSORIES (See figure 15).

The following accessories are mounted on the intermediate and/or rear case of each engine: fuel pump, hydraulic pump, tachometer generator, starter, alternator, blower shift actuator, fuel flow transmitter, carburetor and water regulator. The cabin supercharger compressor is mounted on the right hand engine only and some of its associated units are mounted in the accessory section of the nacelle. Refer to Chapter 17 for details.

Drain lines for the engine supercharger hydraulic pump, fuel pump and transmitters terminate at a common manifold in the accessory section (see figure 14). The crankcase breather and fuel pump vent line are also connected to the same manifold.

Chip detectors are located in the bottom of engine accessory case. Metal chips are detected by attaching a buzzer or ohmmeter with one lead to the brass connection in center of detector and other lead grounded to engine. If chips are present in the plug, the buzzer or ohmmeter indicates such by the plug making a direct ground to engine completing circuit.

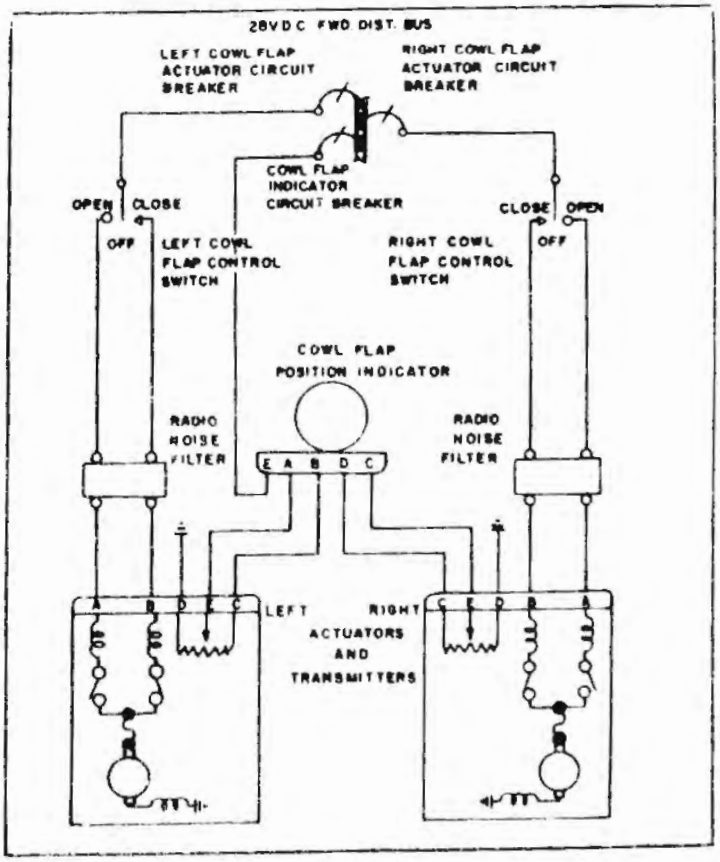


Figure 4A. Cowl Flap Indication Schematic

IGNITION SYSTEM

Each engine ignition system consists of a low tension magneto, two low tension distributors, a harness with nine detachable primary leads, eighteen dual high tension coils and thirty six high tension leads.

The magneto generates a low voltage current which is transmitted through the distributors, to the high tension coils located on each cylinder. Here the current is transformed to the high voltage required at the spark plugs.

OPERATION OF IGNITION SYSTEM (See figure 6)

Figure 6 is a simplified schematic diagram of the 18 cylinder high altitude ignition system, showing the basic principle of operation.

MAGNETO OPERATION

In the magneto are two four-pole magnets mounted on the same shaft, but staggered 45° from each other. Also in the magneto are two sets of double pole shoes and four primary coils. As each magnet rotates one revolution, it produces in each of the two coils on its pole shoes four impulses of current. Since the magnets are staggered 45° from each other, there are eight current impulses per revolution of the shaft. Since each impulse is generated in two coils, each impulse is of dual nature. There are, therefore, eight consecutive dual impulses of low-voltage current produced for each revolution of the magnet shaft. The magnet shaft is driven at one and one-eighth times engine speed, producing nine double-spark impulses per engine revolution.

There are no secondary windings in the magneto, so the current is at a relatively low voltage, or low tension. It is due to this fact that the system is called a low tension ignition system.

HARNESS AND DISTRIBUTORS OPERATION

These low-voltage impulses are transmitted through the harness to the distributors. The impulses from the two right hand coils in the magneto, "R-1" and "R-2", are carried to the right hand distributor, which fires the front plugs in each cylinder. The two left hand coils

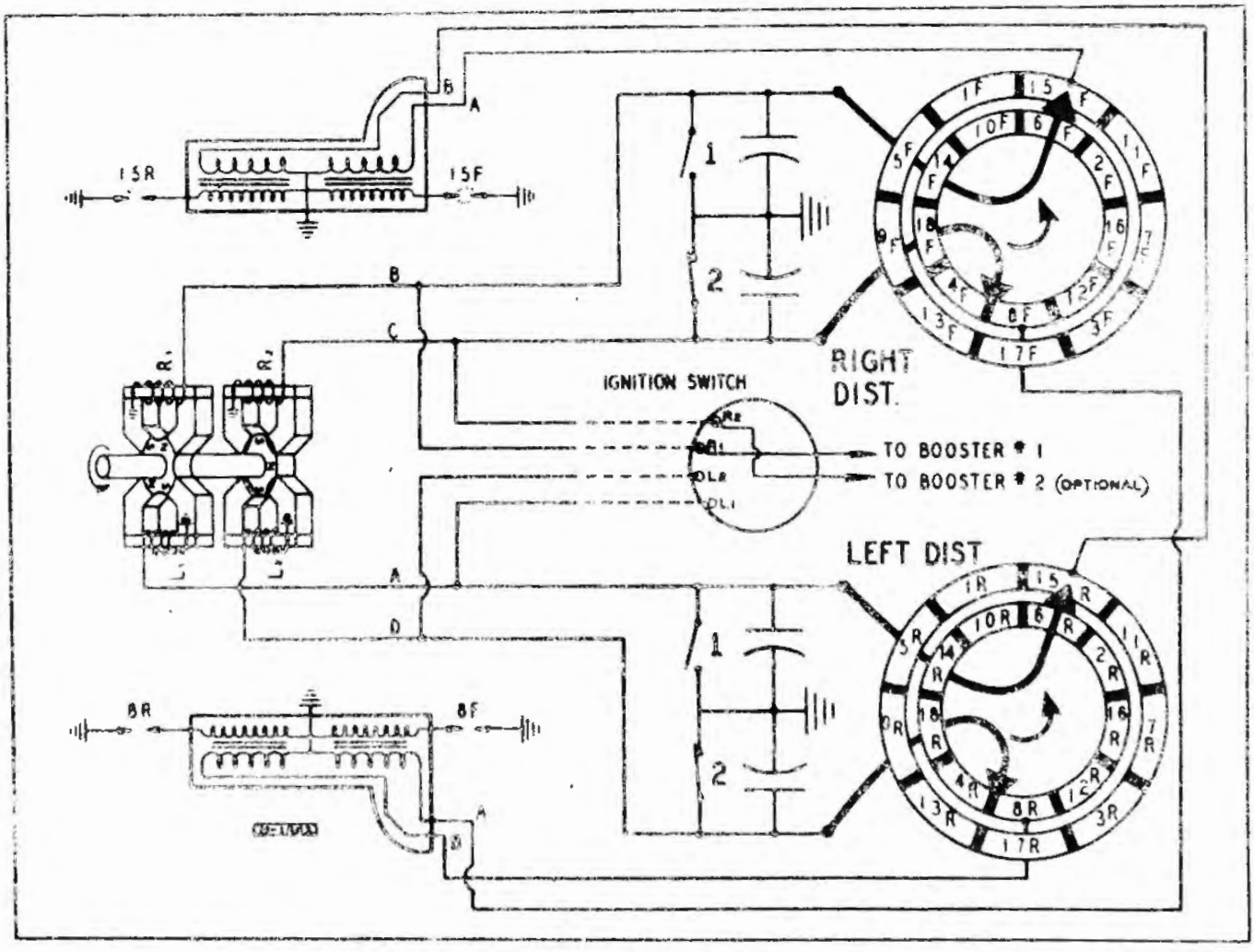


Figure 6. Engine Ingition System Schematic

in the magneto "L-1" and "L-2", are connected to the left hand distributor, and fire the rear plugs in each cylinder. As long as the breaker points are closed, there are two completed circuits in each distributor. One is through the breaker points to ground and back to the grounded primary coil. The other is out through the distributor, into the primary winding of the high tension coil. This second circuit has a relatively high resistance, so most of the current will flow through the breaker points, the circuit having relatively low resistance. When the primary current reaches its peak value, the cam separates the breaker points, and interrupts the circuit through the points.

Transformer Coil Operation

Current is then transmitted through the primary winding in the transformer coil, and since it was at its peak value, it goes as a terrific surge. This surge induces a very high voltage in the secondary winding, which has enough electrical pressure to break down the gap between the electrodes of the spark plug and cause a spark between them. The surge of secondary current is very short lived. It falls away quite rapidly, then the points close again and reconnect the low resistance circuit to ground. Meanwhile, of course, the finger of the distributor has made contact with the proper segment of the distributor block, so that the surge is directed to the particular spark plug which it is desired to fire. Now as the magnet rotates, and another impulse is building up in the primary circuit, the finger moves to the next distributor segment, and the next plug in the firing order will receive the coming surge. Also, the two distributors are synchronized and when the right one is firing a front plug the left is firing the rear plug in the same cylinder. Therefore, the two plugs in any one cylinder are each receiving a high voltage surge at the same moment assuring satisfactory ignition of the gas charge in the cylinder.

How A Spark Is Produced

Figure 6 will clarify the action circuits at the instant of firing a cylinder. Assume that No. 15 cylinder is being fired. This cylinder is 17th in the firing order. Coils "L1" and "R1" are generating impulses in the magneto. The current goes through the harness to the distributors, "L1" to the left distributor, "R1" to the right distributor. Since the breaker points are opened, the current flows into the distributor finger, through the carbon brushes and to the No. 17 segment which is connected to the coil for No. 15 cylinder. It then flows through the harness to the coil for No. 15 cylinder where it is transformed into high voltage current and passes through the high tension lead to the spark plug, causing a spark at the gap. The current from the left distributor is transmitted to the rear plug, and the current from the right distributor is transmitted to the front plug. After this surge of current has ceased, the distributor finger will progress from No. 17 segment to No. 13 segment and coils "L2" and "R2" in the magneto will be generating impulses which will be transmitted to cylinder No. 8, the 18th cylinder in the firing order.

Magneto.

The type DLN-10 magneto used on the R-2800 low tension system is of double tandem four pole magnet design and is of anti-clockwise rotation. There are no secondary windings. One end of each coil winding is grounded to the magneto housing. The other end is connected into the harness.

The magneto is mounted on the front of the engine by means of a standard four bolt flange. The housing and cover are of cast magnesium alloy and are secured together with a special clamping ring to provide adequate radio shielding.

A timing disc with four marks that correspond to the four "E gap" positions is installed on the magneto rotor and a reference index is mounted on the body of the magneto. These are visible through a viewing window in the top of the magneto cover. The disc and index are used to locate the "E gap" position; this was previously done by the plunger on the side of the magneto.

The low voltage impulses from the magnetos are transmitted through the harness to the distributors. These impulses in turn are channeled through the distributors to the transformer coils and high tension leads to the plugs. The impulses from the two right hand coils in the magneto, "R-1" and "R-2" are carried to the right hand distributor, which fires the front plug in each cylinder. The two left hand coils in the magneto, "L-1" and "L-2", are connected to the left hand distributor, and fire the rear plugs in each cylinder.

Each coil assembly consists of two transformer coils assembled into a single case. These coils receive low-tension current and step it up to high tension leads to the plugs. The impulses from the two right hand coils in the magneto, "R-1" and "R-2" are carried to the right hand distributor, which fires the front plug in each cylinder. The two left hand coils in the magneto, "L-1" and "L-2", are connected to the left hand distributor, and fire the rear plugs in each cylinder.

There are two engine ignition switches located on the pilot's overhead panel. Each switch has the following positions, "OFF", "R", "L" and "BOTH". When a switch is placed in the "OFF" position, all magneto circuits connected to the switch are grounded. In the "BOTH" position this ground is removed. When the switch is placed to the "R" position, the left side of the magneto is grounded and the engine is running on the right side of the magneto and the front plugs. The reverse is true should the switch be placed in the "L" position.

Harness Assembly And Primary Leads.

The harness assembly consists of a tubular metal manifold to which are permanently attached the bases for the two distributors. The manifold carries nine primary lead outlets, one magneto connection and one switch connection. All the outlet connections are four pin plug in electrical connectors.

Within the manifold are 44 primary (low tension) wires. Four wires run from the magneto connector (two to each of two distributors), and 36 wires run from the contact segments of the distributors to the primary lead outlets of the manifold. All wires within the manifold are number 18 gauge, insulated with rubber and fabric.

The distributor bases contain the distribution blocks over which the carbon brushes of the distributor finger travel in making the proper distribution of current to the engine cylinder coils. Short lead wires, attached to each segment plate, make the electrical connections to the distributors which fit within the distributor bases of the harness.

The detachable primary leads connect the harness outlets to the transformer coils. Each primary lead is of forked construction, having a four pin electrical connector at the manifold end, and a two pin connector at each of the branches which lead to the two coils.

Within each distributor base an oil seal is mounted. The sealing ring of the oil seal assembly mates against a lapped washer on the drive shaft of the distributor unit, thereby preventing the engine oil from entering the distributor.

Distributor Assemblies.

The distributor assemblies fit within the distributor bases of the harness assembly. They are of clockwise rotation as viewed from the drive end. (Note that the rotation is anti-clockwise as one looks into the distributor base at the segment plate.) Each distributor is secured in position with three screws and is provided with a precision machined cover. The cover is secured with a clamping ring which insures an electrically tight seal, preventing radio interference.

The distributor shaft carries two nine lobe compensated breaker cams, a distributor finger, and the drive coupling. It also carries a lapped washer which mates against the sealing member of the oil seal in the distributor base. The breakers are mounted adjacent to the cams and are secured to a breaker plate mounted on the distributor housing. A condenser is connected across each breaker, the condenser being mounted to the housing with clamps.

The molded collector plate is mounted directly over the distributor finger. The two collector rings in this plate make contact with the two carbon brushes on the upper surface of the distributor finger. The upper brushes are connected through the finger to the lower brushes, which make contact with the distributor blocks in the distributor base section of the harness.

The breaker cams are of compensated design. The number one lobe of each cam is marked with a dot. Each cam is also engraved with an arrow to show the direction of operating rotation. The upper cam is designated as number one and operates the number one breaker which in turn controls the firing of the rear row of engine cylinders. The lower cam operates with the number two breaker and controls the firing of the front row cylinders.

The distributor shaft turns on two ball bearings and is driven at 1/2 engine crankshaft speed. The drive end of the shaft carries a coupling of standard 17 tooth design. The upper end of the shaft is machined to provide a timing step which is used in conjunction with two timing marks to indicate the opening positions of the two breakers.

The drive coupling of the distributor is provided with vernier ratchets to permit accurate setting of the distributor when timing it to the engine.

Transformer Coils And High Tension Leads.

Each coil assembly consists of two transformer coils permanently assembled into a single case and wired to suitable electrical connections. The coil units are mounted on special brackets secured to the baffle plates of the engine cylinders.

A two pin electrical connector forms the input connection to the coil assembly. One pin of the connector leads to the primary of each transformer coil. The other end of each primary is grounded. One end of each secondary is also grounded. The other end of each secondary terminates at a high tension contact socket, one of which is at each end of the coil base.

Each high tension lead fits directly into one of the high tension contact sockets of its respective coil. The leads are short, thereby reducing energy losses in the system.

WATER INJECTION SYSTEM (A.D.I.).

On all engines, an excessively rich mixture is used for full engine powers. This unburnable gasoline in each cylinder cools the incoming charge by its evaporation, and detonation is thereby reduced or prevented. Water injection further advances this principle by use of a mixture of water and alcohol in place of fuel, as it is considerably more effective as a coolant than gasoline, thus permitting the throttle to be opened wider without detonation, allowing 300 more horse power per engine to be produced in this installation.

The principal components of this system are: water regulators, tank assembly, pump, quantity transmitter and indicator, solenoid operated supply shut-off valves, pressure switches, solenoid operated vapor vent valves, manual firewall shut-off valves, strainer, pressure transmitters and gages and pressure warning units and indicators.

Operation of The Water Injection System (See figure 17).

When the "WATER INJECTION" switch, which is located on the overhead switch panel, is turned "ON", the water injection pump and the vent solenoid valves are energized and a positive feed is supplied to the oil pressure switches. The vent solenoid valves, being normally closed, will open when energized, and provide a passage for water return from regulator to tank. Since the pump is now operating, water pressure is available at the solenoid operated shut-off valves in the left wing fillet. These valves are normally closed and depend upon the oil pressure switches to complete the circuit to open them. If the engines are operating, engine oil pressure (must be above 20 psi) actuates the pressure switches which in turn complete the circuit to the solenoid operated shut-off valves, causing them to open. Water then flows through a check valve and a manual shut-off valve and thence to the regulator on each engine.

Water is available to the engines at any rpm, providing the "WATER INJECTION" switch is in the "ON" position and rear engine oil pressure is above 20 psi.

Water pressure at the regulator is utilized to close the derichment valve of the carburetor. Closing of the derichment jet does not affect substantially the fuel-air ratio in the low and medium power range. This is because the derichment jet and the power enrichment jet are in parallel and cutting off the fuel flow to the derichment jet does not affect fuel-air ratio until the capacity of the power enrichment jet is reached or exceeded. The capacity of the power enrichment jet is reached at the point in the power range where the fuel-air ratio normally reaches best power. With "WATER INJECTION" switch "ON", the capacity of the power enrichment jet is sufficient to provide best power mixture through the entire power range, being supplemented by water for cooling in the upper range. During dry take-off the additional fuel flow derived from the derichment jet serves to supplement the power enrichment jet through the dry power range which is limited to 2700 RPM and 55 inches MAP.

Water Injection Quantity Indication System.

The water injection quantity indication system is a Magnesyn-type system containing a quantity transmitter located on the bottom of the A.D.I. tank and an indicator located on the pilots' instrument panel. Refer to Chapter 23 for principle of operation.

Water Injection Strainer Assembly.

The strainer is installed in the pressure feed line in the immediate vicinity of the water injection tank and forward of the water injection pump. It prevents the entrance of dirt and foreign matter which is not picked up by the pump strainer.

The strainer may be removed by disconnecting the two tube connections and removing the clamp assembly which attaches it to the structure. The strainer elements may be removed for cleaning by breaking the safety wire on the wing nuts and unfastening the hinged cover plate. A seal is mounted between the cover plate and housing and its condition should be checked upon reinstallation of the strainer elements.

Water Injection Check Valve.

A check valve is installed in the supply line to each engine to prevent the entrance of gasoline into the water injection system in the event of a rupture of the diaphram in the derichment valve of the carburetor. These valves are simple spring-loaded check valves with a pressure drop of approximately two psi across the valve at the alcohol-water flow rate required for the engine.

These valves are located in their respective wheel wells, just aft of the firewall and are supported by the tubing in which they are connected. In replacing a check valve, position it so that the arrow points forward.

Solenoid Operated Water Supply Shut-Off Valves (See figure 7).

A solenoid-operated shut-off valve is installed in the supply line to each engine to prevent the flow of water to the engine when the engine is not operating. These valves are operated by their respective rear engine oil pressure switches which are located on the top aft side of each nacelle firewall. When engine oil pressure builds up to approximately 20 psi, the oil pressure switch completes the circuit to the solenoid operated valves. When oil pressure drops below 25 psi, the circuit is again interrupted, causing the solenoid shut-off valve to close.

The solenoid valves are located in the left wing fillet, near the water injection strainer, and are accessible through the water injection

tank access door. These valves may be removed by disconnecting the electrical plug and the tube connection at each end of the valve.

Neither the solenoid operated shut-off valves nor the oil pressure switches normally require servicing between overhauls. In the event of malfunctioning of either unit, the unit should be replaced.

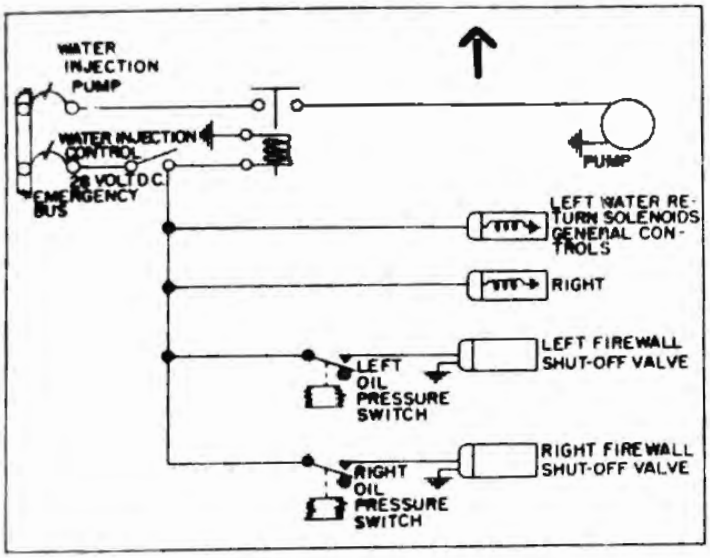


Figure 7. Water Injection System Electrical Schematic

Water Injection Vent Solenoid Valves (See figure 8).

A solenoid operated valve is installed in the vapor return line from each water regulator. These valves are spring loaded in the closed position and are opened electrically when the "WATER INJECTION" switch is turned "ON". When water injection is not being used, these valves prevent the flow of fuel into the water injection tank in the event there is leakage of fuel through the regulator seals. See figure 7 for electrical circuit.

These valves are located in the left wing fillet aft of rear spar at wing station 55 . There are no adjustments possible on these units and malfunctioning is cause for replacement.

Water Supply Manual Firewall Shut-Off Valve.

The manually operated shut-off valve is located on the aft side of the firewall at approximately WL29 and is controlled by the "SELECTOR ZONE 2" handle mounted just below the glare shield in the pilots' compartment. This valve is operated at the same time the fuel, oil and hydraulic valve is operated. The valve has only two positions, "OFF" and "ON" and due to the method of attachment cannot be installed out of phase. Refer to Chapter 19 for rigging instructions.

Water Injection Tank.

The water injection tank (A.D.I.) is located in the aft end of the left wing fillet and is accessible through a large door in the bottom of the fillet. A smaller door within this large door provides access to the pump within the tank and to the bottom filler. The tank which is cylindrical in shape, is equipped with a rubber liner and has a capacity of 15 U.S. gallons. Two clamp assemblies attach the tank to the fuselage. The top filler for the tank is accessible through a hinged access door in the side of the wing fillet. This door is color coded with a red and gray bullseye, however the first planes delivered will be coded red and white. The top filler tube is equipped with a removable screen to prevent foreign matter from entering the tank.

The tank is equipped with a submerged pump, a water quantity transmitter, a scupper and vent line fitting, all of which are removable while the tank is installed in the airplane.

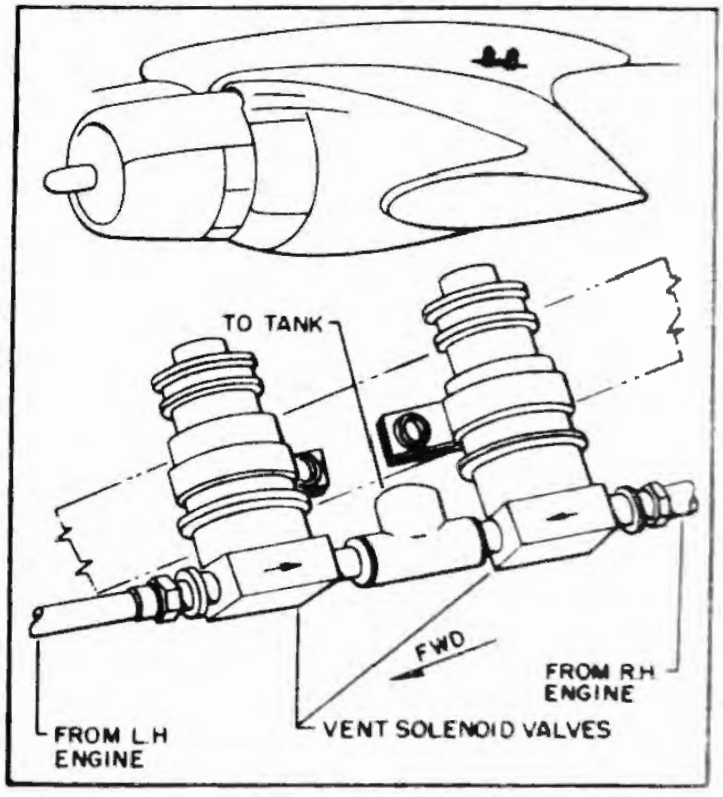


Figure 8. Vent Solenoid Valves

Water Injection Pump (See figure 9).

The pump, Romec model RG8825, is a non-pulsating positive displacement, rotary vane type and is driven by a 1/5 horsepower series and shunt wound motor. The armature speed is 8400 rpm at 27 volts and draws 11 amperes. The pump speed is 2800 rpm.

The unit is submerged in the tank and mounted to the bottom of the tank by the pump flange and bolt ring, with a gasket between the pump flange and tank. External water discharge outlet and electrical leads connect through the flange. The flange also contains a pump

inlet strainer, pump seal drain outlet, and a pressure relief valve. There are no connections or adjustments within the tank. The pressure relief valve is adjustable in the range of 20 to 45 psi Refer to "ADJUSTMENT OF WATER INJECTION PUMP".

Power for the operation of the pump is supplied from the "EMERGENCY" bus through a circuit breaker on the main circuit breaker panel and a water pump relay located on the right hand distribution panel in the electrical hatch. The pump relay is energized by the "WATER INJECTION" switch. See figure 7 for schematic details.

Water Pressure Indicating System (See figure 16).

This system consists of a pressure transmitter and indicator for each engine and also a pressure warning unit and indicator for each engine.

Water Pressure Transmitter And Indicator. (See figure 16).

The magnesyn type water pressure transmitters are located on the transmitter rack in the accessory sections. The upper tube connection is a vent which drains overboard. The lower connection is the water pressure inlet. The pressure indication is electrically transmitted to a gage in the center instrument panel. This gage has a range of 0-35 psi.

Water Pressure Warning Unit And Indicator. (See figure 16).

A pressure warning unit is located on the transmitter rack in the accessory section of each engine and its indicator light is located directly below its respective water pressure gage on the center instrument panel. When water pressure drops below tolerance, the warning indicator switch is actuated which causes the indicator light to glow.

Whenever the pressure line to the warning unit has been disconnected or replaced, it may be necessary to bleed the air out of the line in order to prevent intermittent operation of the indicator light. To bleed the system, it is only necessary to loosen the pressure connection at the transmitter while the system is under pressure then retighten connection.

Water Injection Regulator (See figure 10).

The water regulator is a non-hesitating variable water-air ratio regulator and is mounted on the intermediate rear section of the engine, just below the carburetor.

The function of the control is to meter the water entering the fuel system in such a manner that the flow of water will be directly proportional to the mass air flow. The water repalces the fuel normally used to cool the combustion charge below the detonation point when operating in the extreme power range, thus effecting fuel economy while at the same time permitting a safe increase in power output for a period of time limited by the amount of water available. This variable flow control provides an enriched water flow for the higher power requirements and a leaner mixture for the lower limits of the extreme power range.

SERVICING OF WATER INJECTION TANKS

The ADI tank filler access is located on top of the left wing fillet. The access is color-coded red and gray as is the ADI fluid replenishing can. These cans have a ten micron filter incorporated in them and it is important that only these cans be used for servicing since the fluid must be filtered through a 10 micron filter before it is put in the ADI system.

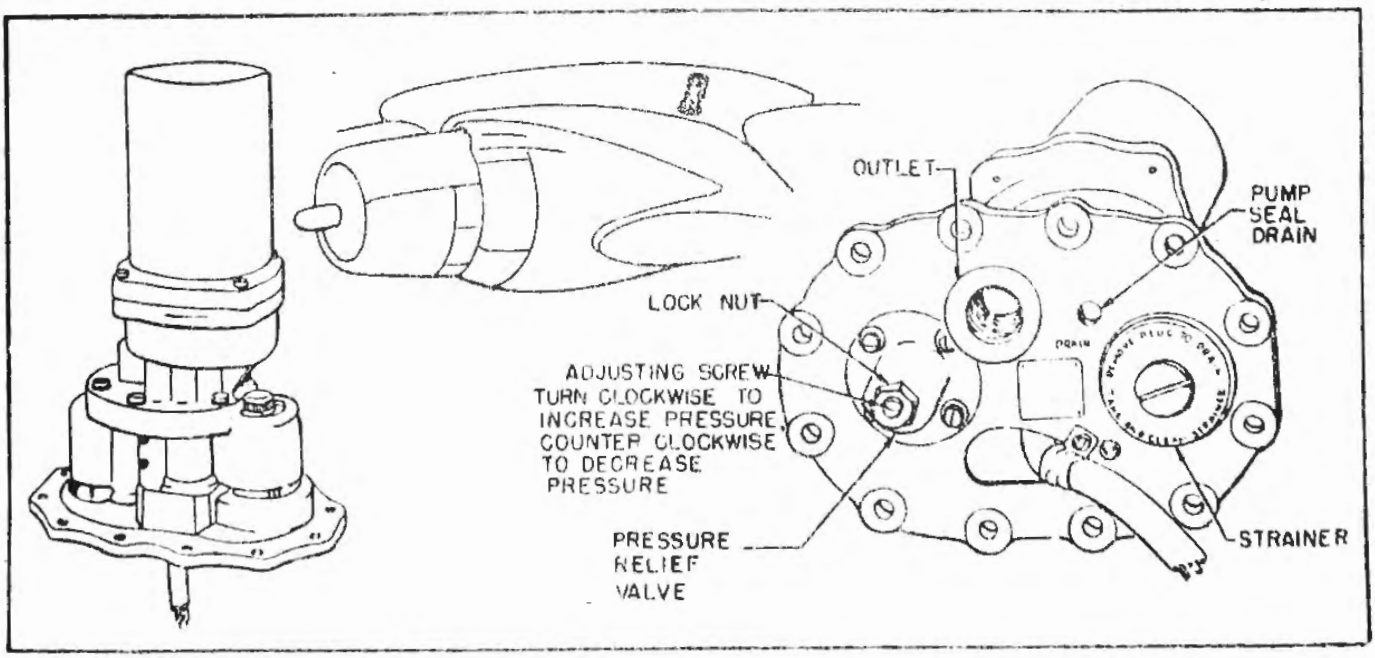


Figure 9. Water Injection Pump

Servicing of Water Injection Tank (cont.)

The ADI tank shall be serviced to capacity with pre-mixed water injection fluid (50% methyl alcohol and 50% water) each time the plane is fueled and at any other time the gauge in the bottom of the tank indicates 11.5 gallons or less. The minimum quantity for take-off is 11.2 gallons.

WARNING

Methyl alcohol (methanol) is extremely irritating to the eyes and skin, poisonous when taken internally and highly inflammable. Treat it as you would leaded gasoline and observe the following:

1. Handle only in well ventilated areas and avoid open handling.
2. Avoid breathing vapors.
3. Do not smoke, use an open flame, or create sparks where methanol is used or stored.
4. Prevent direct contact of methanol with your skin. Wash at once in case of accidental contact.
5. If clothing becomes wet with methanol, change immediately.
6. Use large quantity of water to flush away spills.
7. Properly identify and plainly mark all containers.

First Aid - Water Injection Injury

IF SWALLOWED: Give a tablespoon of salt in a glass of warm water and repeat until vomit fluid is clear. Give two tablespoons full of baking soda in a glass of water. Lay patient down and keep warm. Cover eyes to exclude light. Call a doctor.

IF SPLASHED IN THE EYES: Immediately splash with water for at least 15 minutes. Call a Doctor.

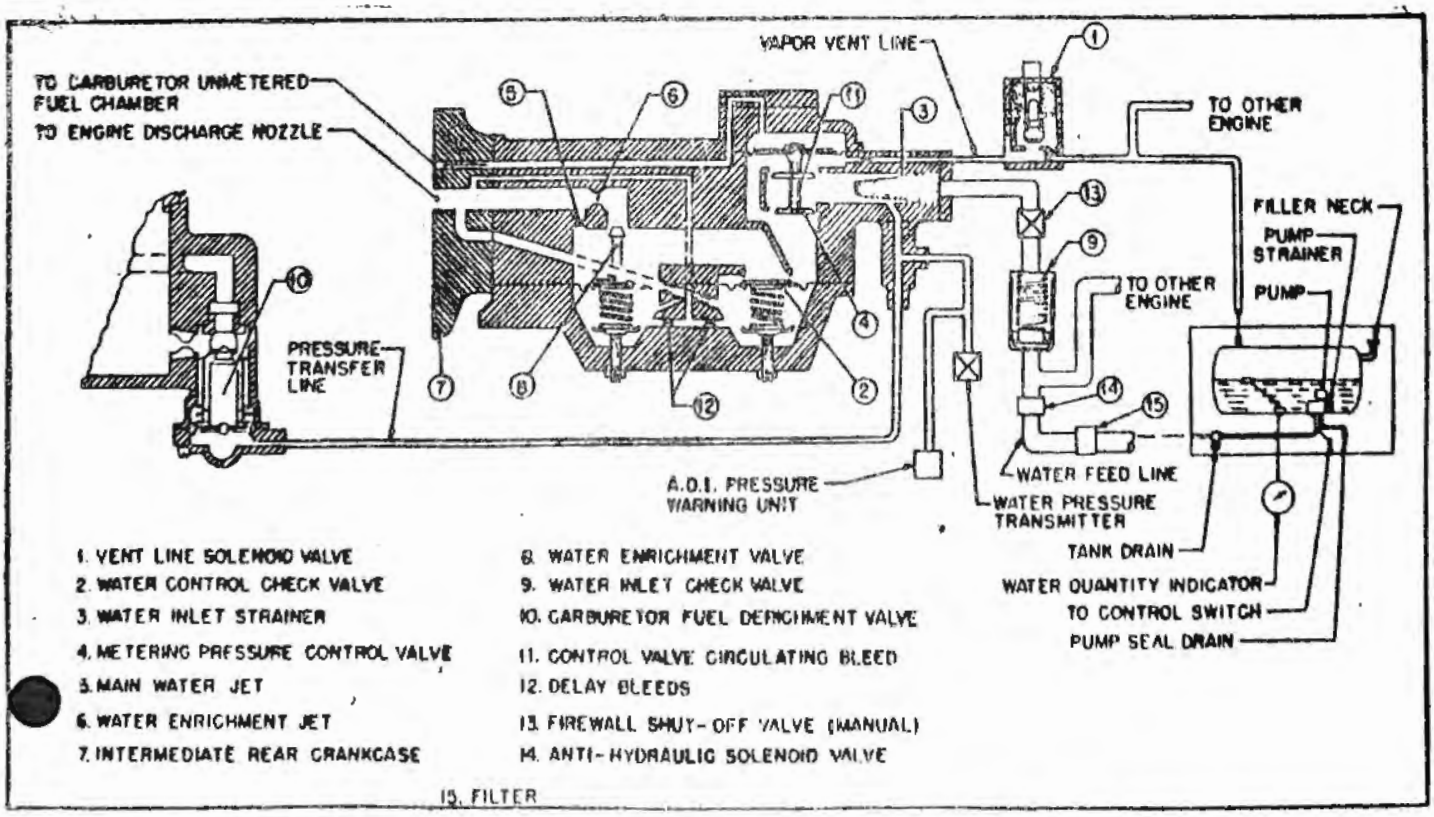


Figure 10. Water Injection Regulator Schematic

ENGINE INSTRUMENTS - GENERAL

The conventional type engine instruments are back mounted on the removable center panel of the pilots' instrument panel. These instruments are all dual reading indicators that provide the pilot and co-pilot with an indication of the performance of each engine. The instruments consist of a manifold pressure indicator, tachometer and synchroscope indicator, oil pressure indicator, oil temperature indicator, B.M.E.P. torque pressure indicator, water injection pressure indicator, fuel pressure indicator, carburetor air temperature indicator and cylinder head temperature indicator. Refer to chapter 13 for the oil system instrumentation, chapter 12 for the fuel system indication and to chapter 23 for principle of operation and a view of the panel.

Manifold Pressure Transmitter (See figure 16).

The manifold pressure transmitter is a magnesyn instrument used to convey the value of pressure existing in the engine manifold to the manifold pressure indicator located on the instrument panel. The pressure in a gaseous form from the engine blower section is measured by the deflection of an evacuated diaphragm in the transmitter and transformed into an electrical signal which is transmitted to the indicator as actual pressure existing in the engine manifold.

The manifold pressure transmitter is located on a shock-mounted support attached to the right hand side of each engine mount.

Manifold Pressure Indicator.

The manifold pressure indicator is a dual, concentric, magnesyn indicator, with two pointers marked "L" and "R". It is used in conjunction with a manifold pressure transmitter. It provides the pilot and co-pilot with an indication of the absolute pressure of the fuel-air mixture being delivered to each engine. The elbow fitting, used to connect the transmitter pressure supply line to the engine intake manifold, is restricted with a #76 drill (.020") size hole.

When either inverter is operating, 26 volt, 400 cycle, single phase a-c power is fed through the pilot's and co-pilot's bus located in the main radio junction box, to the right and left hand manifold pressure transmitters and to the dual manifold pressure indicator on the center panel of the pilot's instrument panel.

Cylinder Head Temperature.

The cylinder head temperature dual indicator, of the ratiometer type, is mounted on the center (engine) instrument panel and is accessible for replacement by lowering the instrument panel. A standard AN thermocouple bulb is installed on the aft side of number four cylinder.

Power for the operation of this circuit is taken from the 28 volt d-c forward distribution bus through the "CYL. HD. TEMP. IND." circuit breaker located on the main circuit breaker panel.

Tachometer And Synchroscope.

The tachometer and synchroscope indicator consists of two synchronous-motor-magnetic-drag tachometer indicators and a synchroscope, all housed in a single case and installed in the center (engine) instrument panel.

The dual tachometer indicators show simultaneously on a single dial the speeds of rotation of the engine crankshafts in revolutions per minute of each engine while the synchroscope shows the relative speed of both engines. When the engines are synchronized (running at the same speed) the synchroscope dial stands still, but when they are running at different speeds, it revolves, indicating that the right engine is running faster or slower than the left engine. An excessive speed difference does not cause the synchroscope dial to revolve, but is indicated by a rocking motion. Rotation of the dial begins as the difference reaches 350 rpm and, as the engines approach synchronism, the dial revolves at a rate equal to the speed difference.

The tachometer indicators are connected electrically to the individual synchronous-motor-magnetic-drag type tachometer generator located on the right hand side of each engine. The synchroscope rotor is connected to the tachometer of the left engine while the stator is connected to that of the right engine.

BMEP Transmitter (See figure 16).

The BMEP transmitter is located on the shock mounted transmitter rack on the right hand side of each engine mount. Its purpose is to measure the engine torque pressure delivered to the propeller shaft and to transmit this measurement to an indicator in the center (engine) instrument panel. The pressure take-off point is at the bottom of the propeller auto-feathering torque pressure switch on the left hand side of the engine nose section. The oil line runs between the top cylinders and thence to the transmitter. This line is anti-iced by the rubber blanket method throughout the power section of the engine. The control for the heater is a circuit breaker, "TORQUEMETER HEATER" for each engine and is located on the main circuit breaker panel.

The pressure source at the nose case take-off for torquemeter oil pressure is removed from the auto feather switch cap and relocated at a point below the top of the switch on the aft side. The tube fitting threaded into switch is restricted with a #50 drill size hole.

It is necessary for the pressure supply line between the transmitter and nose case adapter be filled with fluid at all times for proper operation of the system. See Index for reference to filling instructions.

BMEP Indicator.

The BMEP indicator is a dual concentric instrument electrically connected to the pressure transmitter and located on the center engine instrument panel. Access for replacement may be gained by lowering the instrument panel.

BMEP INDICATOR
BMEP Indicator (Cont.)

The indicator has a range of 60 to 250 psi and includes the conversion formula on its face to enable one to compute the brake horse power being developed by the engine.

When either inverter is operating; 26 volt, 400 cycle, single a-c power is supplied through the pilot's and co-pilot's bus to the left and right transmitter and to the indicator through the "TORQUE PRESS." fuses, "R. ENG." and "L. ENG." located on the radio junction box fuse panel.

OIL SYSTEM - GENERAL (See figure 6).

A separate gravity feed, dry sump oil system, with provisions for cooling and diluting the oil, is provided for each engine.

The component parts of each system, besides the oil pressure pump, scavenger pump and oil passages which are a part of the engine itself, are: oil tank with filler, dip stick, hopper and sump, sequence valve, oil cooler and regulator valve, oil dilution solenoid and shut off valve, oil cooler air scoop, oil cooler flap and actuator, a firewall shut-off valve and an indicating system for oil cooler flap position, oil temperature, oil pressure and oil quantity.

OPERATION OF THE OIL SYSTEM (See figure 6).

Oil supply to the engine flows from the tank to the firewall shut-off valve and thence to the engine driven pump on the aft face of the engine accessory section. This pressure pump forces the oil through the engine. Oil return from the engine is directed to the regulator valve on the oil cooler. The regulator valve, through its temperature sensing mechanism, determines whether the oil flows through the oil cooler, oil cooler muff, or by-passes the cooler entirely and goes directly to the tank by way of the sequence valve. The sequence valve is mounted on the tank directly above the tank hopper and is controlled by oil temperature also. This valve determines whether the return oil goes into the hopper, tank proper or both.

FILLING AND DRAINING OIL TANK.

Engine oil tanks shall be serviced with 100 or 120 grade oil each time the plane is serviced. Oil filler access is on the top right hand side of each nacelle aft of the firewall. The access door is identified by a name plate and due to a safety device cannot be closed unless the filler cap is properly installed and locked.

OIL TANK (See figure 8).

The oil tank is of welded aluminum alloy construction and has a nominal capacity of 27.0 gallons plus a 4.5 gallon expansion space. The tank is mounted in a padded cradle at the top of each nacelle and is supported by two strap and yoke assemblies which facilitate quick removal and installation. Three bolt rings are attached to the interior of the tank by means of screws and nuts. The top ring serves a dual purpose: it serves as the sequence valve nozzle and as a mounting ring for the sequence valve. The two bottom rings are for the quantity transmitter and the sump assembly. A scupper assembly is welded to the tank and it houses the filler neck and dip stick assembly. The tank is vented to the engine crankcase. The oil tanks are interchangeable between engines and airplanes.

FILLER CAP, DIP STICK AND SCUPPER (See figure 8).

The scupper is welded to the tank and houses the filler neck and dip stick. A rubber boot is provided between the scupper and the nacelle to prevent oil from entering the nacelle area due to inadvertent overflowing the scupper during servicing. The scupper is also provided with a drain. Access to the scupper is gained by opening the placarded access door on the right hand side of each nacelle.

The filler neck has a wire mesh screen and is topped by a standard U.S.A.F. filler cap. An extension is attached to the cap to prevent the access door being closed with the cap loose in the scupper. The cap must be properly installed and locked before the access door can be closed.

The dip stick is located in the scupper and provides the only physical means of checking the oil quantity at the tank. Refer to series three for dip stick graduation.

HOpper And Sump (See figure 8).

This spotwelded assembly is attached to the bottom of the tank by 18 bolts. The engine oil supply line and the propeller auxiliary pump supply are taken off at the sump and their connections extend high enough in the sump to prevent any normal accumulation of sludge from entering the lines. The propeller auxiliary pump connection is such that a two gallon reserve is maintained for emergency feathering operation even though the engine pump supply is exhausted.

The tank drain valve is mounted on the bottom of the sump. It is spring loaded in the closed position and is provided with an outlet for attaching a standard hose for draining the tank.

OIL COOLING SYSTEM (See figure 10).

The oil cooling system for each engine consists of an air scoop, oil cooler and regulator valve and oil cooler flap and actuator. This assembly is mounted to the right of the bottom centerline of each engine at the accessory section.

OIL COOLER AIR SCOOP (See figure 10).

The air scoop is the mounting for all components of the cooling system and must be removed in order to replace the oil cooler. The scoop forms a part of the accessory section cowling and is interchangeable between engines and airplanes. Openings in the lower lip of the leading edge of the scoop provides cooling air for the accessory compartment and generator. A blast tube is connected to the scoop by means of an adapter. The scoop is provided with a fire detector and a carbon dioxide discharge nozzle. Refer to Chapter 19 for further details.

Oil Cooler Flap and Flap Actuator (See figure 10)

An electrically operated screw-jack actuator, mounted on a support brace on the cooler air scoop drives a push-pull rod connected to the

Oil Cooler Flap And Flap Actuator (Cont.).

flap. A seal assembly fits around the rod and is forced down on a seal box on the top of the duct by a spring and collar assembly. The upper portion of the spring is threaded around a short piece of rubber hose to prevent wear on the actuating rod. The actuator has a normal retracted length of 13 5/32 inches and a normal extended length of 18 5/32 inches. The length of time for a complete stroke is approximately 30 secs. and the duty cycle is 3 minutes on 17 minutes off.

Two "OIL COOLER FLAP" switches, one for each actuator, are located on the overhead switch panel. They receive their power from the forward distribution bus through the "OIL COOLER FLAP ACTUATOR" circuit breaker. Limit switches on the actuator are adjusted for this particular installation and should normally not be tampered with. A potentiometer is incorporated in the center (engine) instrument panel. Refer to Oil Cooler Flap Actuator Replacement And Adjustment.

Oil Cooler And Regulator Valve (See figure 2).

The cooler is a 16 inch aluminum axial flow type and is mounted in the oil cooler air scoop by two strap assemblies. To facilitate installation, the word "FWD" is stenciled on the top of the oil cooler.

The regulator valve is mounted directly on the cooler and its purpose is to direct the flow of oil at the cooler and to protect the cooler from excessive oil pressures.

The oil cooler and regulator valve will normally require no maintenance between overhaul periods but may be replaced separately if either unit leaks or if the regulator malfunctions during service. Refer to Index for Oil Cooler And Regulator Valve Replacement. If minor adjustments to temperature operating range of the regulator are considered necessary, they may be made by loosening the adjustment lock screw and turning the adjustment screw clockwise to decrease and counter clockwise to increase temperature. A one quarter turn of the adjustment screw changes the temperature range approximately 5 degrees Fahrenheit (see figure 1).

OPERATION OF THE OIL COOLER REGULATOR VALVE. (See figure 2).

The manner in which the valve functions is best understood by describing what takes place from the moment the engine is started in cold weather until normal operation is attained. It is assumed that no oil dilution was used at engine shut-down.

Cold Start Operation (See figure 2).

When the engine is started in cold weather high pressures are built up. These high pressures are prevented from reaching the oil cooler proper by the action of the surge valve at the regulator oil inlet and the check valve at the oil outlet. When the pressure at the inlet valve reaches 60 to 70 psi, the guided valve begins to lift off its seat and the pressure is relieved to the surge protection by-pass at the top of the valve. The pressure is prevented from reaching the core at the oil outlet by the check valve covering this port. There is thus a clear pass for the oil from the inlet through the valve to the outlet line. It is

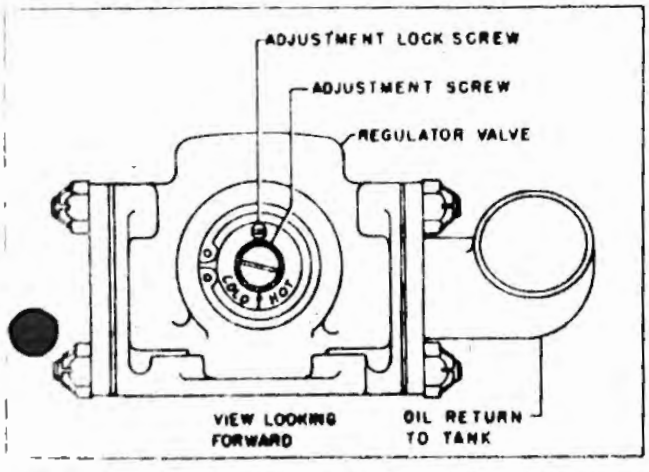


Figure 1. Oil Cooler Regulator Valve Adjustment

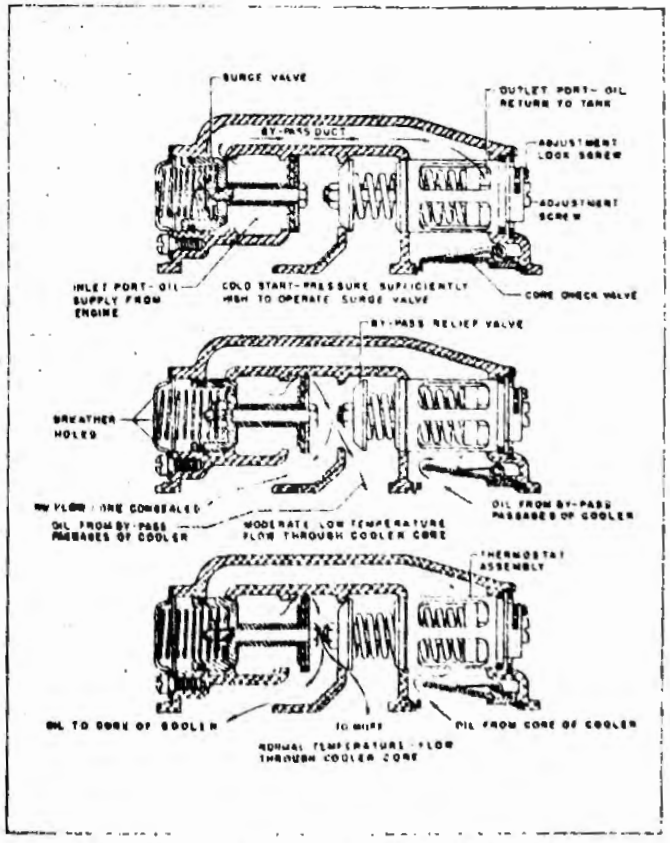

SURGE VALVE
OUTLET PORT- OIL RETURN TO TANK
BY-PASS DUCT
ADJUSTMENT LOCK SCREW
ADJUSTMENT SCREW
INLET PORT- OIL SUPPLY FROM ENGINE
COLD START- PRESSURE SUFFICIENTLY HIGH TO OPERATE SURGE VALVE
CORE CHECK VALVE
BY-PASS RELIEF VALVE
BREATHER HOLES
OIL FROM BY-PASS PASSAGES OF COOLER
MODERATE LOW TEMPERATURE FLOW THROUGH COOLER CORE
THERMOSTAT ASSEMBLY
OIL TO CORE OF COOLER
OIL FROM CORE OF COOLER
NORMAL TEMPERATURE FLOW THROUGH COOLER CORE

Figure 2. Oil Cooler Regulator Valve

Cold Start Operation (Cont.).

noted that the surge protection poppet valve has as yet not closed off the port leading to the cooler inlet, and may not do so on all cold starts since the oil which has been by-passed through the partly opened guided valve port may be sufficient to clear the outlet line, and it is noted that the pressure on the core is limited to 60 or 70 psi, which figures will be referred to as 65 psi in the following.

The oil in the outlet line, however, may be congealed to such an extent that the 65 pounds pressure developed at the outlet port will not be sufficient to clear the line. The pressure will then continue to build up until the line is cleared and, as it does so, the surge protection valve moves further and the poppet valve eventually seats. The pressure at the moment of closing is 98 psi maximum, and the core is protected from further pressure increase.

When the valve and outlet line to the oil tank are cleared of congealed oil, the pressure at the oil valve inlet falls rapidly and the guided valve will be opened sufficiently to pass the oil at a pressure drop of 65 psi. The poppet valve is again open and the inlet to the cooler is subjected to 65 psi. The first step of the operation of the valve is now finished, and the second step, namely warm-up of the cooler and its congealed oil, begins.

Warm-Up Operation (See figure 2).

The thermostat is set to regulate the oil temperature at 165 degrees Fahrenheit. Under the conditions we have just considered the oil is cold: the thermostat is, therefore, contracted and the poppet valve at the end of the thermostat is off its seat. It is thus apparent that, besides the flow passage from the cooler inlet through the cooler core to the cooler outlet, which is temporarily blocked by congealed oil, there is a second and shorter path in parallel through the by-pass to cooler outlet. This by-pass has large passages and with a pressure of 65 pounds applied at the inlet, it is soon cleared of oil. The oil by-pass is in intimate contact with the passages of the cooler core itself, and as the oil now flowing through the by-pass is heated up by the heat generated in the engine, heat is transmitted to the congealed oil in the cooler and a thawed out passage is created in the cooler core itself, parallel to the by-pass flow. Oil begins to flow into this cleared passage and out thru the cooler check valve, over the thermostat and to the outlet. Further heating up of the oil expands the thermostat, which eventually closes the port to the by-pass and all the flow reaching the valve now passes to the cooler core. Although the entire core is not thawed out and though further warm-up continues, the warm-up period proper is over and the valve now functions normally.

Normal Operation (See figure 2).

When the cooler core is "warmed up" and normal oil flow established, the only function performed by the valve is temperature regulation. If the oil temperature leaving the valve is above the temperature at which the valve is set to regulate, the thermostat closes the port to the by-pass inlet and all the oil flows through the cooler core. When the temperature of the oil leaving the valve tends to fall below its regulating temperature, the thermostat partly opens its port so that oil is flowing through the by-pass in parallel with the cooled oil. The hot and cooled oil mixes in the last pasa of the by-pass channel and flows through the check valve and across the thermostat to the outlet, so that the thermostat is sensing the temperature of the mixed oil, opening further if the temperature falls and closing if the temperature tends to increase. The thermostat itself is entirely independent of ambient air and regulates the oil to the same temperature whether at ground level on a hot summer day or at 50,000 feet altitude in air at -65°F.

By-Pass Relief Operation (See figure 2).

The thermostat assembly incorporates a spring loaded relief valve, the action of which so far has not been explained since it may function in any or all of the above steps. Should it happen during warm-up, the thermostat has expanded and attempts to close its port while the by-pass is still filled with congealed oil, the thermostatic by-pass relief valve comes into action. This spring loaded valve, which is mounted at the end of the thermostat, opens at a minimum of 32 psi and, since oil is flowing to the valve, there is a pressure of 65 psi applied to the inlet. In other words, although the thermostat attempts to close its port, the relief valve opens and a pressure of 33 pounds is applied at the by-pass inlet. This pressure eventually clears the by-pass and establishes warm-up.

In cold weather flight, the oil pressure drop in the oil cooler tends to build up, especially during a glide with idling engines, and part of the cooler core may congeal. When the throttle is suddenly opened and the oil flow increased, the partly congealed cooler may not be able to flow the oil at a safe pressure and the by-pass relief valve now comes into play as the first relief around the cooler core. If the by-pass channel is also congealed, the pressure will increase further. The guided valve will open, by-passing the entire cooler through the valve. From this point onwards, the action is the same as normal thaw-out; that is, the by-pass channel will be cleared and the flow passages of the cooler gradually enlarged until the cooler is able to take the increased flow at normal pressures.

Oil Tank Sequence Valve And Nozzle (Cont.).

The sequence valve is a thermostatically controlled poppet and disc type valve and it serves four purposes:

1. Directs cold oil to hopper
2. Directs hot oil to tank
3. Directs diluted oil to hopper
4. Aids in escapement of air entrained with oil.

This valve shall not be adjusted except at time of overhaul and no service is required between overhauls. Access to the valve is gained through an access plate on the top left side of each nacelle.

Operation Of The Sequence Valve (See figure 4).

If the temperature of the oil entering the sequence valve is below 120 degrees Fahrenheit (48.9 degrees Centigrade), it is directed to the hopper. As the oil temperature increases to the above value, the thermostat senses this and starts to open, allowing oil to go to hopper and tank. When the oil temperature reaches 158 degrees Fahrenheit (70 degrees Centigrade) the valve will be fully open, allowing all return oil to go to the tank proper. Should there be some restriction in system between the valve and the main portion of the tank, the disc valve in the sequence valve will relieve through the ring seat under a pressure differential of 55 psi thereby limiting the force imposed against the restriction. Bleed holes are provided to keep the hopper full and to keep the oil behind the valve warm so as to prevent congealing of oil in the valve.

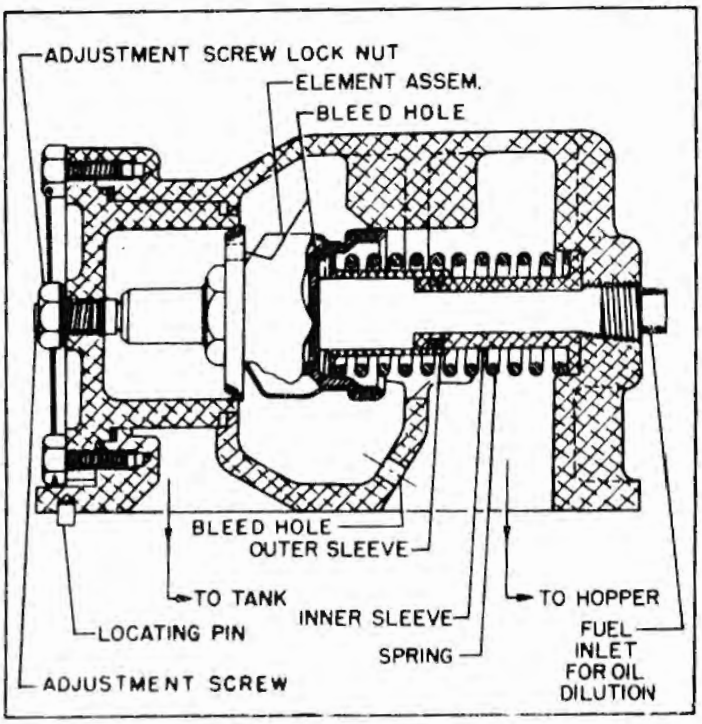


Figure 4. Oil Tank Sequence Valve

If the oil is hot and it is desired to dilute it, the sequence valve will direct the diluted oil to the hopper. As the fuel for dilution enters the sequence valve, it chills the thermostat. In about 12 seconds, the valve shuts off oil flow to main portion of tank and directs the diluted oil to the hopper. The thermostat will not move the valve into position to direct the oil into the main portion of the tank for several minutes after oil dilution; therefore, diluted oil will not be directed to the main portion of the tank even though the engines are operated for one or two minutes after fuel flow ceases.

Oil Dilution System (See figure 7).

Each oil dilution system consists of a solenoid-operated oil dilution valve, manual fuel shut-off valve and a restrictor fitting at the dilution valve. These components are located in their respective main wheel wells, just aft of the main strainer. The manual fuel shut-off valve is accessible from the ground only and should be lockwired in the closed position at all times except during an actual oil dilution period. Fuel is drawn from the main full strainer, through the manual shut-off valve, the oil dilution solenoid and restrictor to the sequence valve. Refer to Chapter 11 for procedure for diluting the oil.

A toggle switch on the overhead switch panel is provided for each engine. When the "OIL DILUTION" switch is moved to the "ON" position, the "HIGH" side of the respective booster pump is energized. The fuel booster pump circuit breaker must be in, but the "FUEL BOOSTER PUMP" switch may be in the "OFF" position. Power is supplied from the circuit breaker to the Zone III anti-icing heater switch or the right inboard anti-icing switch. The remote circuit breaker relay, located in the electrical access hatch, is energized, thus tying the fuel booster pump to the generator bus. Refer to Chapter 26 for wiring diagram of this circuit and to figure (7) for schematic diagram of this circuit. The action of the sequence valve during dilution is explained under "Operation of Sequence Valve."

The introduction of gasoline into the lubricating oil will loosen carbon and sludge deposits within the oil system. This carbon and sludge is carried to the engine oil screen and collects there in quantities sufficient to collapse the screen. Consequently, within an hour or two after the dilution is first used in the season, the screen must be removed for inspection and cleaning.

CAUTION

This inspection must be repeated at short intervals until sludge and carbon no longer exists. Should this precaution be overlooked, collapsed screens are certain to result. Refer to appropriate work sheets for time intervals for this inspection.

OIL SYSTEM INDICATING AND WARNING SYSTEMS - GENERAL.

Indicating systems are used with the engine oil system to provide visual indications of engine oil pressure, oil pressure warning, oil temperature, oil quantity and oil cooler flap position. Each indicating system incorporates a transmitter connected electrically to an indicator on the center (engine) instrument panel as shown on the appropriate wiring diagrams. See applicable sub-title below for further details of the individual indicating systems. Refer to Chapter 23 for principles of operation of the various systems and for a view of the instrument panel.

OIL PRESSURE INDICATING SYSTEM.

The oil pressure indicating system consists of two pressure transmitters and a dual pointer indicator. These systems are a magnesyn type operated on a 26 volt single phase 400 cycle a.c. power supply. Refer to wiring diagrams for circuit details and Chapter 23 for principles of operation.

Oil Pressure Indicator.

The oil pressure indicator, mounted on the center (engine) instrument panel, is a dual pointer type magnesyn indicator. Access for replacement of the indicator may be obtained by lowering the instrument panel.

Oil Pressure Transmitter (See figure 5.).

The oil pressure transmitter is mounted on the lower deck of the transmitter rack secured to the right side of each engine mount forward of the firewall.

The transmitter is mounted on the oil pressure warning unit in such a manner that a common oil pressure supply line connected to the warning unit serves both units.

The fitting at the accessory section (see figure 3) incorporates an .0635 inch (#52 drill size) restrictor to reduce pump pulsations and minimize loss of oil in the event of line leakage.

OIL PRESSURE WARNING SYSTEM.

Two oil pressure warning systems, one for each engine, are used. Each system consists of a warning unit connected to a red warning indicator light on the center (engine) instrument panel. Refer to wiring diagrams for the electrical circuit and to Chapter 23 for view of panel.

Oil Pressure Warning Units (See figure 5.).

An oil pressure warning unit is attached to the oil pressure transmitter by a seal and adapter plate. The warning unit consists of a Bourden tube and pair of electrical contacts. Motion (expansion and contraction) of the Bourdon tube, due to pressure change, is transmitted to one of the contacts while the other contact is stationary. Normal pressure applied to the warning unit mechanism during engine pump operation holds the contacts apart. However, if the pressure drops below a pre-determined value (see Series 13-3) the contacts will close, causing the warning light on the center (engine) instrument panel to glow.

Maintenance is limited to a visual inspection of the unit for mounting and leaks. Malfunctioning is cause for replacement. The unit may be removed by disconnecting the oil-in line and removing the two attaching bolts. Upon installation of a serviceable unit, a new gasket should be used between the warning unit and adapter plate and between the warning unit and pressure transmitter.

ENGINE OIL PRESSURE TRANSMITTER AND WARNING UNIT MOUNTING

The engine oil pressure transmitter and warning unit are mounted on the engine transmitter rack as an assembly (see Figure 5). Due to this installation, additional instructions are necessary as the transmitter may be used on other planes. All serviceable transmitters are stocked with an adapter plate having threaded mounting holes, that must be removed and not used in this installation. The large "O" ring seal, on the face of the transmitter mounting flange, must be removed as it could interfere with the operation of the warning unit mechanism.

Warning units are supplied with "O" ring type seals installed on both sides of the oil manifold in the center of the unit. These "O" rings are the only seals to be used between the transmitter, warning unit, and adapter plate contacting surfaces. Additional gaskets (as shown on Figure 5) are not necessary and could cause oil leakage into the chamber having the exposed bourdon tube and electrical contacts if used.

A special adapter plate, not having threaded mounting holes, must be used at the bottom of the warning unit since anchor nuts are secured to the mount bracket.

ENGINE OIL TEMPERATURE INDICATING SYSTEM.

The engine oil temperature indicating system provides maintenance and flight personnel with temperature indications of the oil entering the engine lubricating system. The system consists of one dual indication of the ratiometer type located on the center (engine) instrument panel, a resistance bulb for each engine and electrical wiring connecting each phase of the dual indicator to its respective resistance bulb and to the airplane power supply. Refer to Chapter 23 for principles of operation and for view of panel. Refer to wiring diagrams for the electrical circuit.

ENGINE OIL TEMPERATURE INDICATING SYSTEM (Cont.).

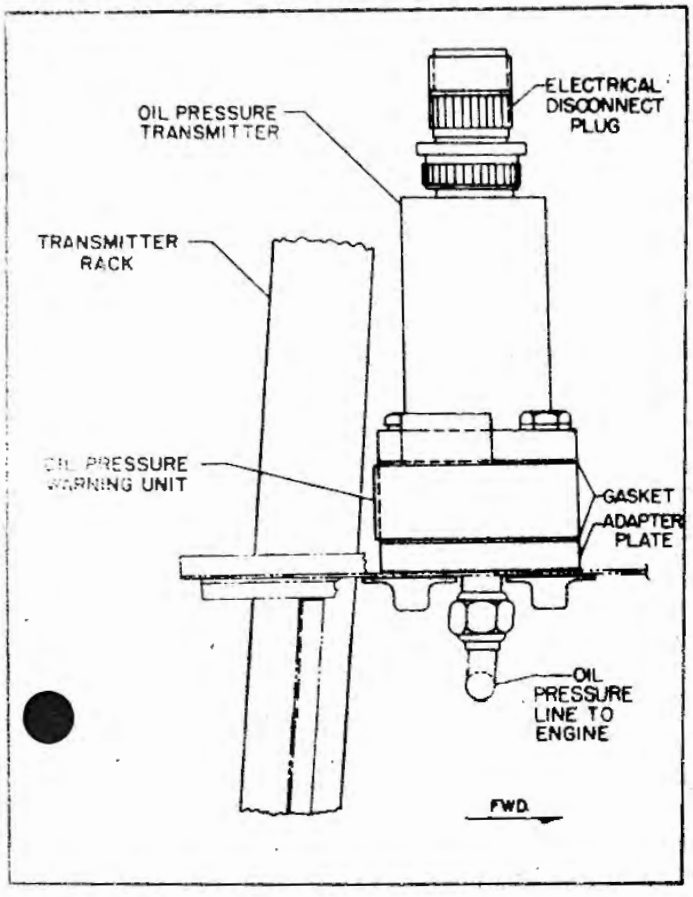


Figure 5. Oil Pressure Transmitter And Warning Unit.

Short stemmed resistance bulbs are used. The bulb is installed above the engine oil outlet line connection near the center aft side of the engine accessory section. A copper asbestos gasket shall be used to provide a seal between the resistance bulb and the accessory case fitting. Provisions have been made for lockwiring the temperature bulb and its disconnect plug.

OIL QUANTITY INDICATING SYSTEM.

The oil quantity indicating system consists of two transmitters and a dual pointer indicator. This system is a magnesyn type operated on a 26 volt single phase 400 cycle a.c. power supply. Refer to Chapter 23 for principles of operation and refer to wiring diagrams for the electrical circuit.

Oil Quantity Indicator.

The oil quantity indicator is a dual pointer type magnesyn instrument mounted on the center (engine) instrument panel. Access for replacement may be obtained by lowering the instrument panel.

Oil Quantity Transmitter.

The oil quantity transmitter is mounted on the bottom of the oil tank in the main wheel well. Its indications are transmitted electrically to the indicator on the center (engine) instrument panel. Refer to wiring diagrams for the electrical circuit and to Chapter 23 for principle of operation. This unit is adjustable and can be adjusted while installed. Refer to Index, this chapter for job procedure.

OIL COOLER FLAP POSITION INDICATING SYSTEM.

The oil cooler flap position indicating system consists of two transmitters and a dual pointer indicator. This system is of the Selsyn type, operated from the 28 volt d-c forward distribution bus. See Chapter 26 for applicable circuit diagram and Chapter 23 for principles of operation.

Oil Cooler Flap Position Indicator.

The oil cooler flap position indicator is a dual pointer type selsyn instrument mounted on the center (engine) instrument panel (see Chapter 23 for panel view). Access for replacement may be obtained by lowering the instrument panel.

Oil Cooler Flap Position Transmitter.

The position transmitter is integral with the flap actuator and transmits movement of the flap to a dual indicator in the center (engine) instrument panel. Refer to index, this chapter, for adjustment procedure.

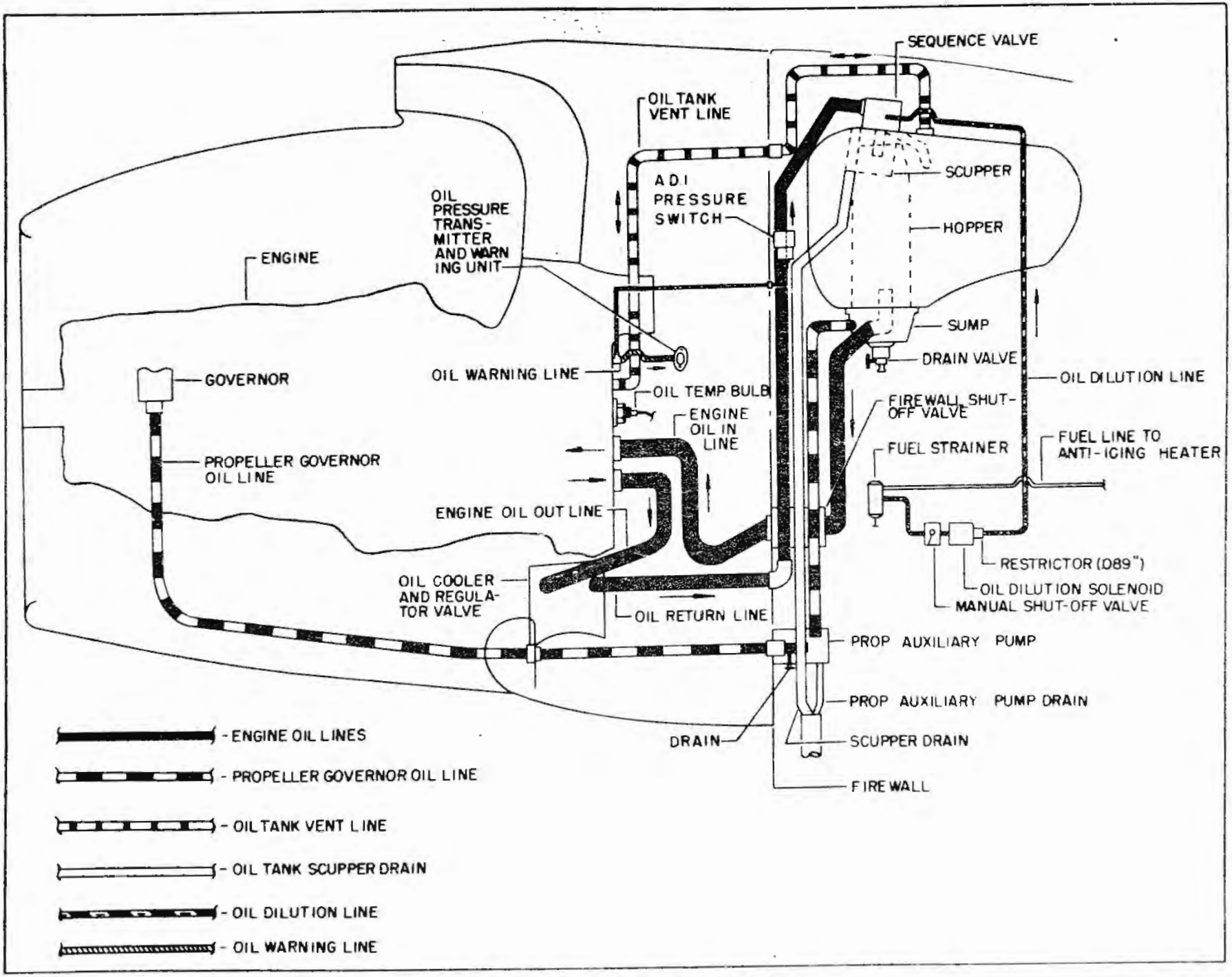


Figure 6. Oil System Schematic

Oil Capacity

Total Tank Capacity - 31.5 U.S. Gallons including 4.5 gallons expansion space.

Service Capacity of Tank - 25 U.S. Gallons

Reserve - 2 Gallons (Propeller feathering oil

Dip Stick Graduation - 5 Gallon increments from 10 to 25 gallons.

Oil Pressure

Adjustment Pressure - 85 +/- 5 psi at 60°C (140°F) oil temperature and field barometric pressure.

Normal Operating Pressure Range

Engine RPM	Oil Pressure
Idling	25 psi minimum
1400	50 psi minimum
1600	85-90 psi
2000-2200	60-100 psi
2200-2800	75-100 psi

Warning Indicator Light

Comes on at 42 +/- 5 psi

Oil Temperature

40°C (104°F) minimum
100°C (212°F) maximum during climb
85°C (185°F) maximum during level flight

Oil Cooler Flap Actuator

Normal retracted length - 13-5/32 inches
Normal extended length - 18-5/32 inches
Normal stroke - 5 inches

Oil Cooler Flap Clearance

Closed Position - 5/8 +/- 1/8 inch (between flap and air scoop)

Sequence Valve

Starts to open - 120°F (48.9°C)
Fully open - 158°F (70°C)

Regulator Valve

Normal thermostat setting - 165°F (73.9°C)

Oil Grade

S.U.S. 100 or 120 at 210°F (98.9°C)

Torque Values

Use standard Torque Values (See Chapter 22).

ENGINE CONTROLS - GENERAL (See figure 1).

The engines are controlled manually by means of a system of levers, bellcranks, cables, quadrants, pulleys and push-pull rods. All of the control levers with the exception of the levers for the firewall fuel, oil, hydraulic and water shut-off valves, which are located in the glare shield in the pilot's compartment, are grouped on the pilot's pedestal. Movement of the control levers is conveyed to quadrants at the base of the pedestal by push-pull rods. From this point loops of cables, broken only by turnbuckles, encircle the fuselage quadrant and pass aft over a pulley bank to the front spar. The cables are then separated into right and left engine control groups, pass through a tunnel in the leading edge of each wing and terminate at their respective firewall quadrants. Push-pull rods connect the quadrants to the engine components. The cable pulleys in the nacelles are of aluminum alloy and all others are made of phenol fiber. Adjustment of cable tension is facilitated by turnbuckles and fair-leads are used to prevent whipping and excessive vibration.

The majority of maintenance work on these controls can be done from outside of the airplane, with the exception, of course, of the upper pedestal and the firewall shut-off valves. Controls in the fuselage are accessible through the nose wheel well, air conditioning access hatch #80, respective blower access hatch #82, heater access hatch #83 and electrical access hatch #84. Controls in the wing leading edge are accessible through their respective center wing tunnel doors #18. The main gear wells permit access to controls in the nacelles.

ENGINE CONTROL CABLES (See figure 1).

The cables have swaged terminals and are manufactured from 3/32 inch 7 x 7 carbon steel. Attachment of cables to quadrants is by means of nail head fittings. Turnbuckles for adjustment of cable tension are located between fuselage stations 235 and 255 and are accessible through the air conditioning hatch #80. The turnbuckles incorporate a left and right hand thread permitting attachment to the cable terminals. Tension on the cables should be adjusted to 40 ± 5 pounds corrected for standard temperature. Refer to Chapter 22 for cable correction chart.

Pilots' Pedestal Assembly (See figure 3).

The pedestal assembly is located midway between the pilot's and co-pilot's seats. The lower part of the pedestal extends down to the nose wheel well and houses the control quadrant bank, which is accessible by removing the forward pressure seal cover shown in figure 5. The engine manual control levers protruding from the top of the pedestal are throttle, mixture and carburetor air controls. Access to the upper section of the pedestal is gained by removing the access plates on each side of the pedestal.

The locking mechanism located just forward of the pilots' pedestal on the pilots floor is protected from any debris by a lock bar cover and rubber seal along the bottom or contact area of the cover with the pilots floor. A vinyle coated fiberglass boot is also provided around the lock bar override rod and is attached to the lock bar cover. The cover and boot assembly are readily removable to gain access to the looking mechanism.

Throttle And Propeller Reversing Control Levers. (See figure 3).

The throttle and propeller reversing levers are mounted on common shafts located near the center of the pedestal. The throttle levers are moved forward to open the throttles and aft to the normal stop to close the throttles. When the throttles are in the closed position, the propeller reversing lever pivot aft off the throttle levers. The first aft movement of the reversing levers reverses the propeller pitch and further movement aft increases throttle opening. The engine speed can now be increased to 1800 rpm in the reverse pitch. At this point, a spring detent, attached to a bellcrank, rides over a cam giving a feel indication that full throttle has been reached. However, this is only the safe normal maximum power recommended for reverse pitch. In case of an emergency, an additional force of approximately 15 pounds applied to the reversing levers will override the detent, and allow full throttle operation.

A roller is attached to the reversing cam and prevents the reversing mechanism from moving when the throttles are in any position except "CLOSED". Should an attempt be made to reverse the propellers with the throttles "OPEN", the throttles will first be forced aft to the "CLOSED" position, the roller will drop into a pedestal detent and the reversing mechanism will actuate. In like manner, the roller, while in the detent, prevents use of the throttle levers when the propellers are in reverse pitch. The pedestal bellcrank is connected by a rod assembly to the propeller reversing switch in order to control the sequence of propeller reversing and unreversing. Another rod assembly is connected to a pawl which is coordinated with the landing gear locking mechanism and prevents movement of the controls into reverse pitch until immediately after touchdown or after the weight of the airplane is sustained by the landing gear.

NOTE: Some airplanes are equipped with deceleration switches which allow reversing the propellers immediately after touchdown. See series 15-1 for more details and series 26-2 for wiring diagrams.

Two micro switches are located adjacent to the throttle bellcranks and connected to the warning horn and landing gear switch circuit. With the landing gears in the up position, the horn will blow when the throttles are moved aft and approach the "CLOSED" position; indicating that one or both throttles have been retarded too far for safe engine speed while in flight.

Throttle And Propeller Reversing Control Levers (Cont.).

See index this Chapter for location of "Adjustment of Throttle Warning Horn". See Chapter 15 for description of throttle switches and for details concerning landing gear scissor switches, through which the throttle warning system operates.

Throttle Friction Lock (See figure 3).

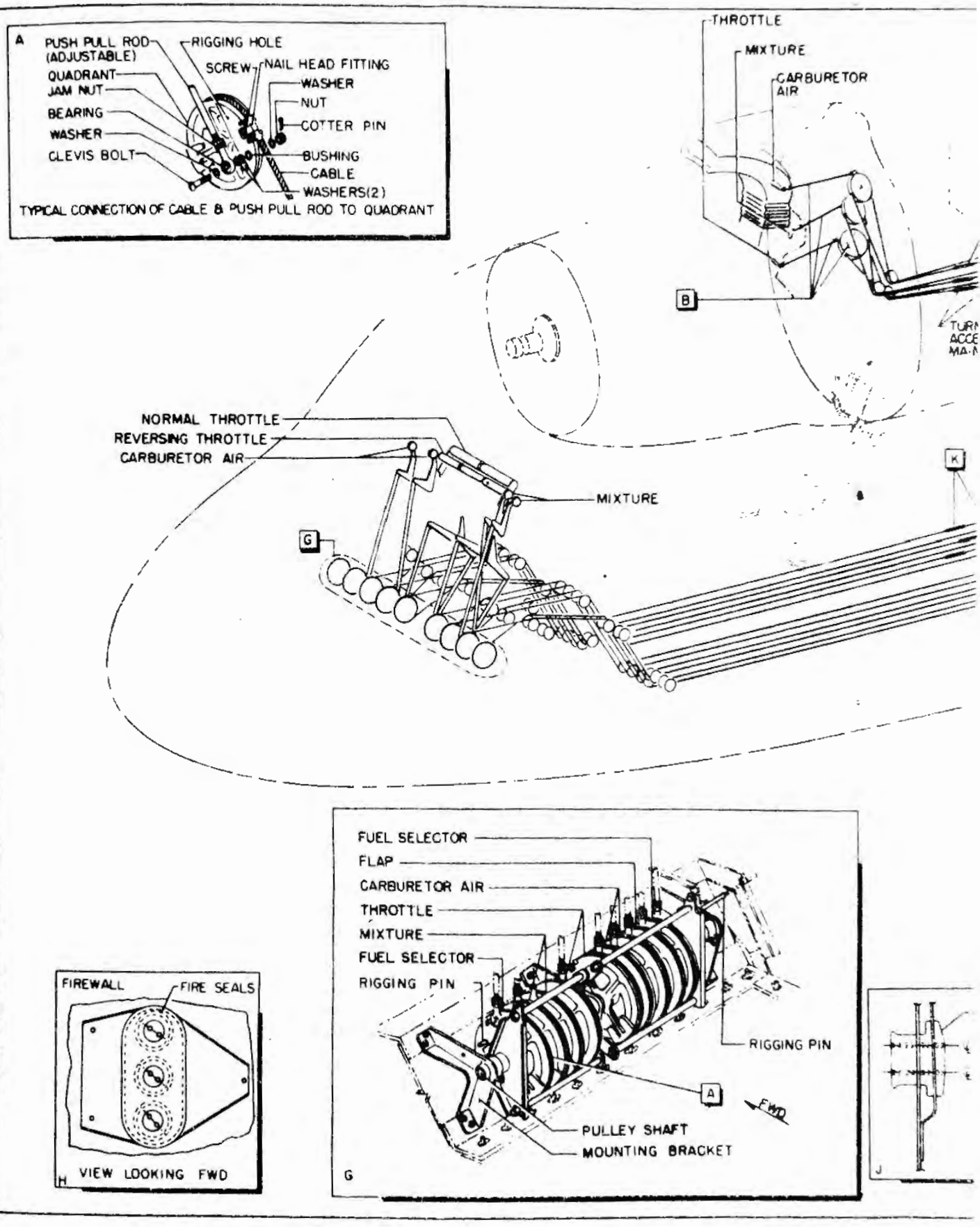
The throttle friction lock lever is located in the center of the pilot's pedestal. Moving the lever forward increases the friction on the throttle control levers and prevents "creeping" when engines are running. The friction lock mechanism consists of three cams, one of which is readily adjustable in flight. A second cam allows the adjustment for normal loss of spring compression strength resulting from usage. The third cam is stationary. Adjustment for the amount of compression, with the friction lock released, is made by loosening the cap screw labeled "LOCK ADJUST", moving the lever and cam aft as far as is necessary and re-tightening the cap screw.

Mixture Control Levers (See figure 3).

The mixture control levers are located near the outboard edge of the pedestal. The levers are moved full forward for "AUTO RICH" mixture, center detent for "AUTO LEAN" mixture and moved to aft detent for "IDLE CUT OFF".

Carburetor Air Control Levers (See figure 3).

The carburetor air control levers are located near the right outboard edge of the pedestal. The levers are moved full forward for the "COLD" position and full aft to the "HOT" position. Any intermediate position may be selected as desired. A ratchet arrangement allows one degree travel increments. Refer to Chapter 11 "Induction Air System" for details.


A
PUSH PULL ROD (ADJUSTABLE)
RIGGING HOLE
SCREW
NAIL HEAD FITTING
WASHER
NUT
COTTER PIN
QUADRANT
JAM NUT
BEARING
WASHER
CLEVIS BOLT
BUSHING
CABLE
WASHERS(2)
TYPICAL CONNECTION OF CABLE & PUSH PULL ROD TO QUADRANT
THROTTLE
MIXTURE
CARBURETOR AIR
B
NORMAL THROTTLE
REVERSING THROTTLE
CARBURETOR AIR
MIXTURE
G
K
FUEL SELECTOR
FLAP
CARBURETOR AIR
THROTTLE
MIXTURE
FUEL SELECTOR
RIGGING PIN
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VIEW LOOKING FWD
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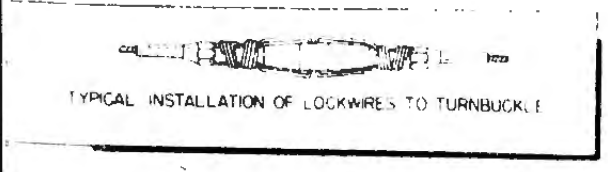
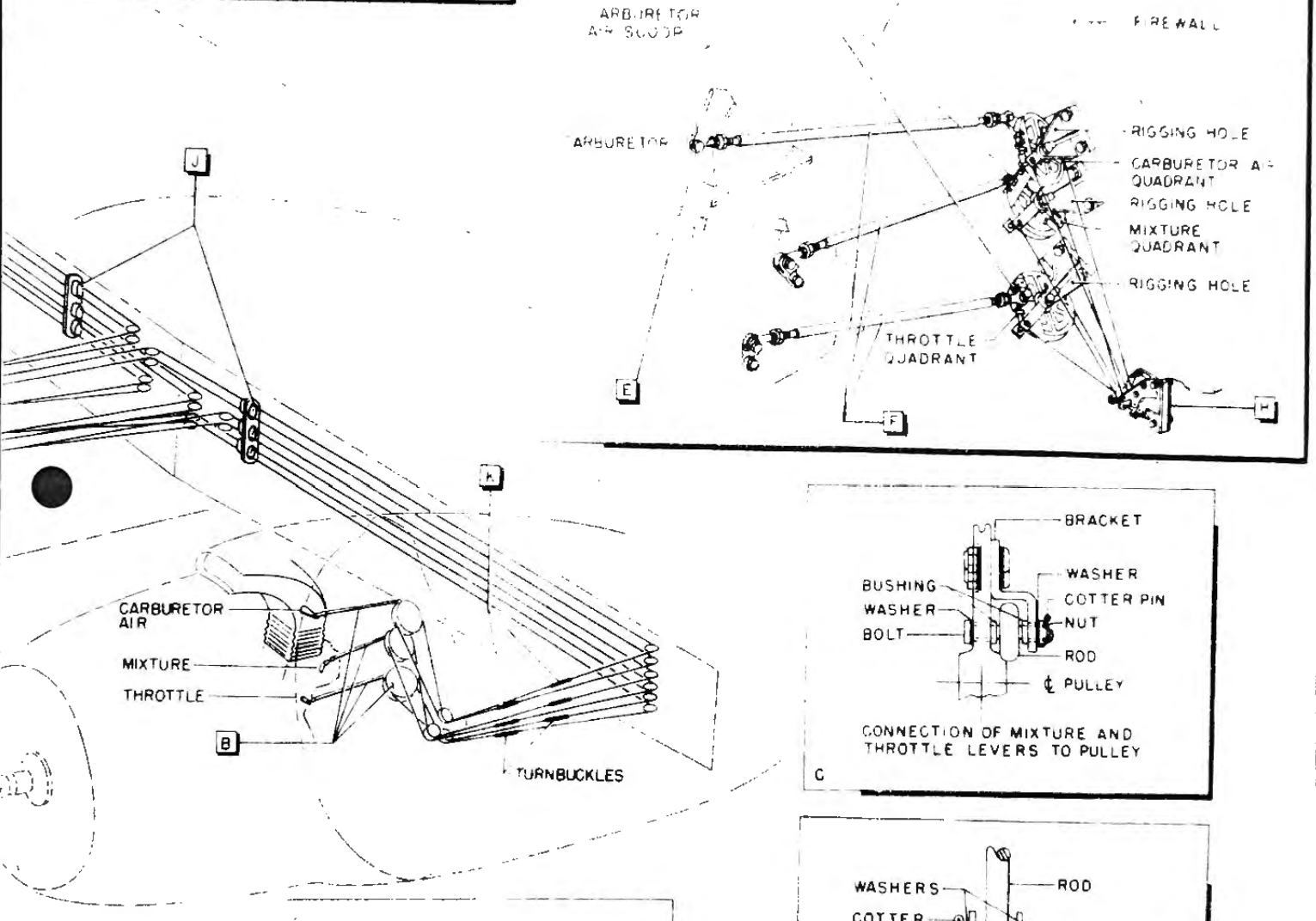
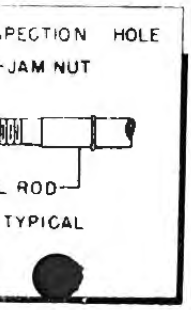


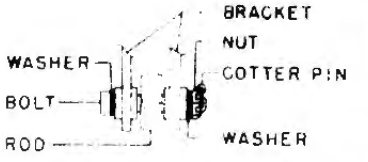
TYPICAL INSTALLATION OF LOCKWIRES TO TURNBUCKLE



CONNECTION OF MIXTURE AND THROTTLE LEVERS TO PULLEY

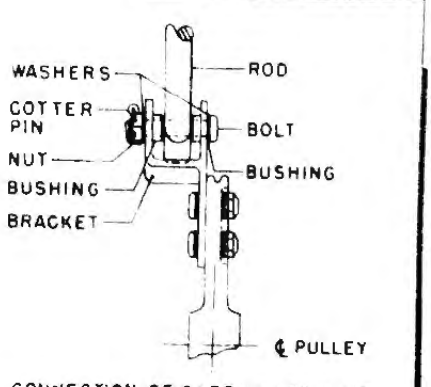
C





CONNECTION OF CARBURETOR AIR INTAKE LEVER TO R J ALSO TYPICAL AT MIXTURE AND THROTTLE LEVERS

E



CONNECTION OF CARBURETOR AIR INTAKE LEVER TO PULLEY

D

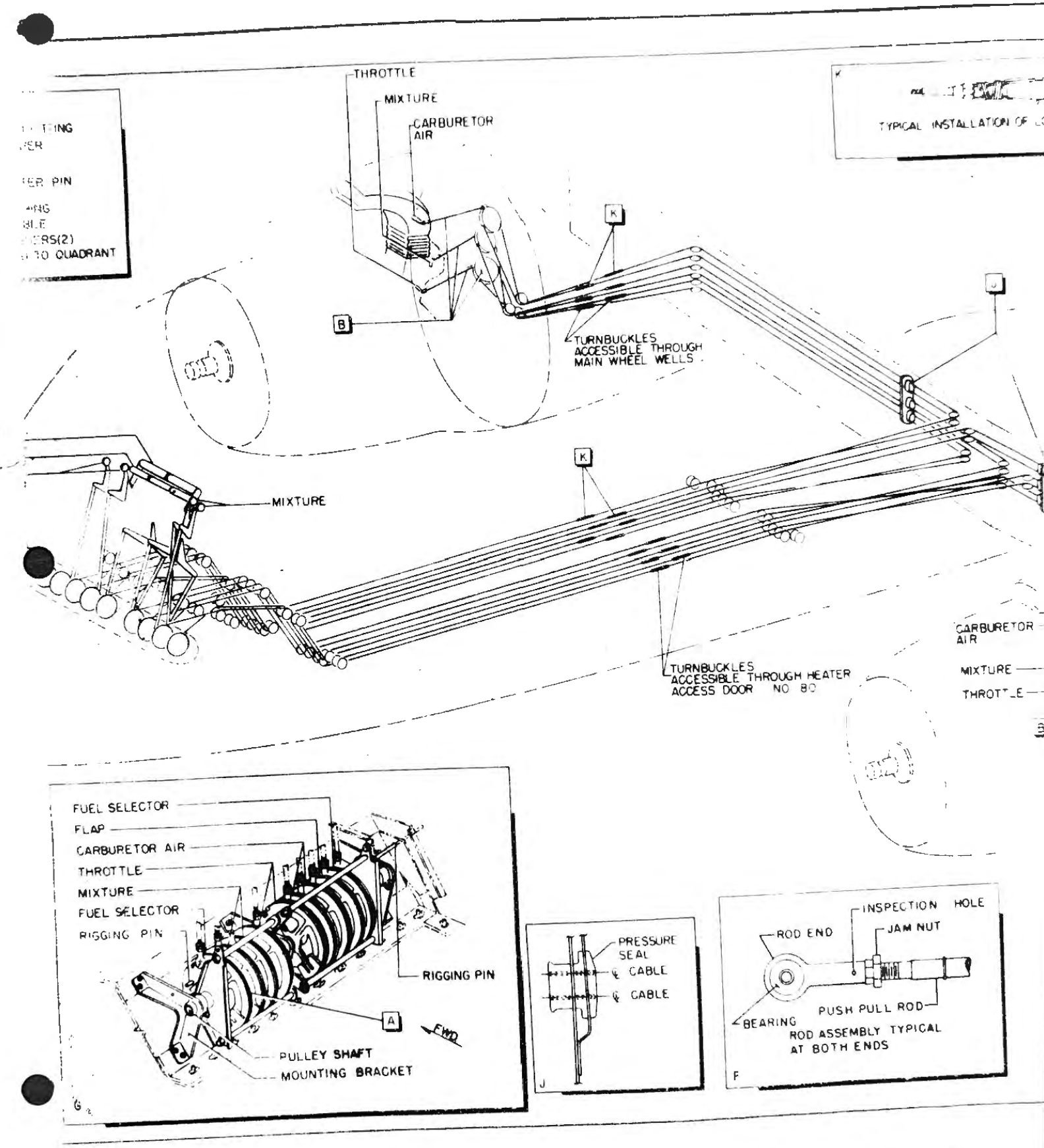


Figure 1. Engine Controls

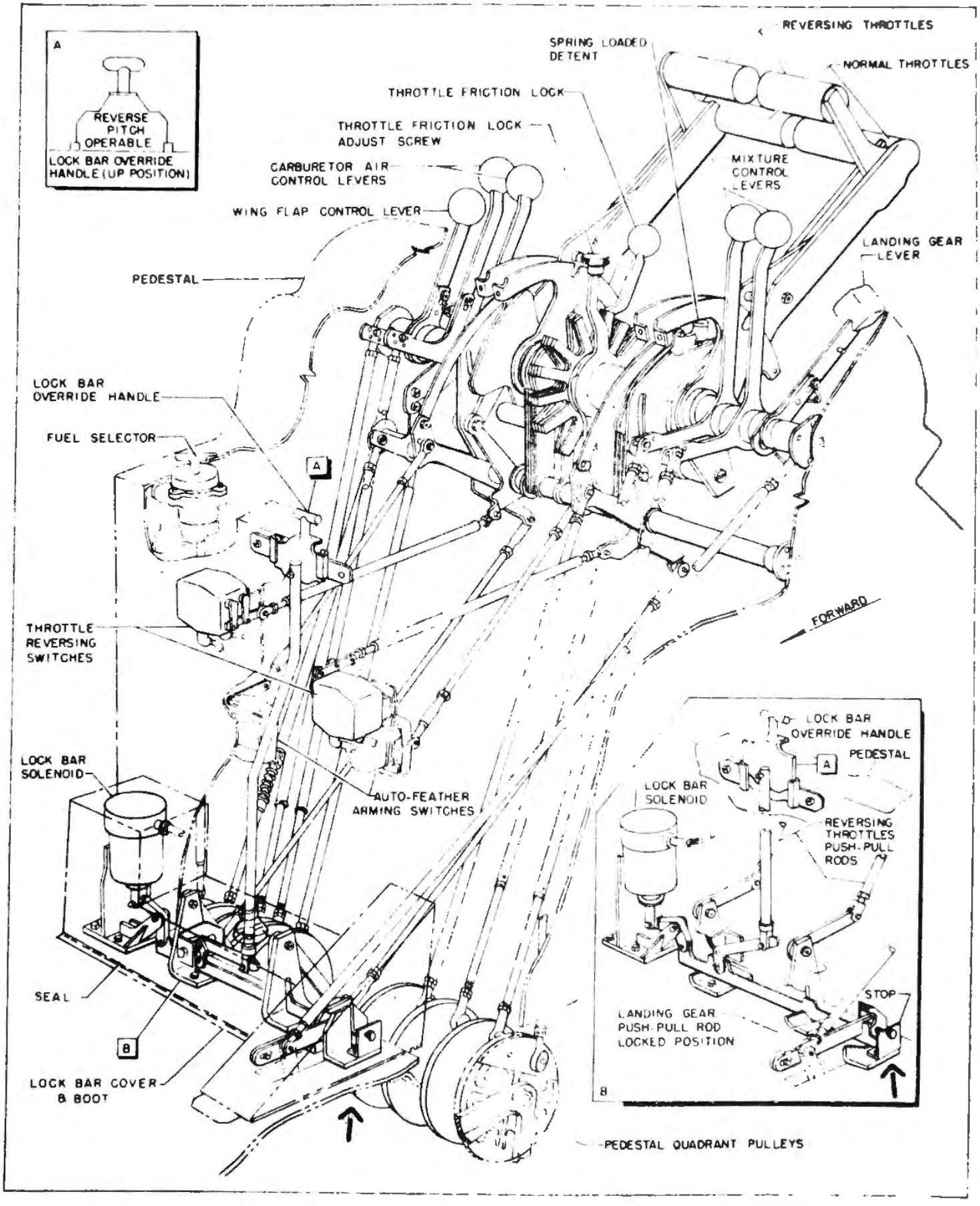
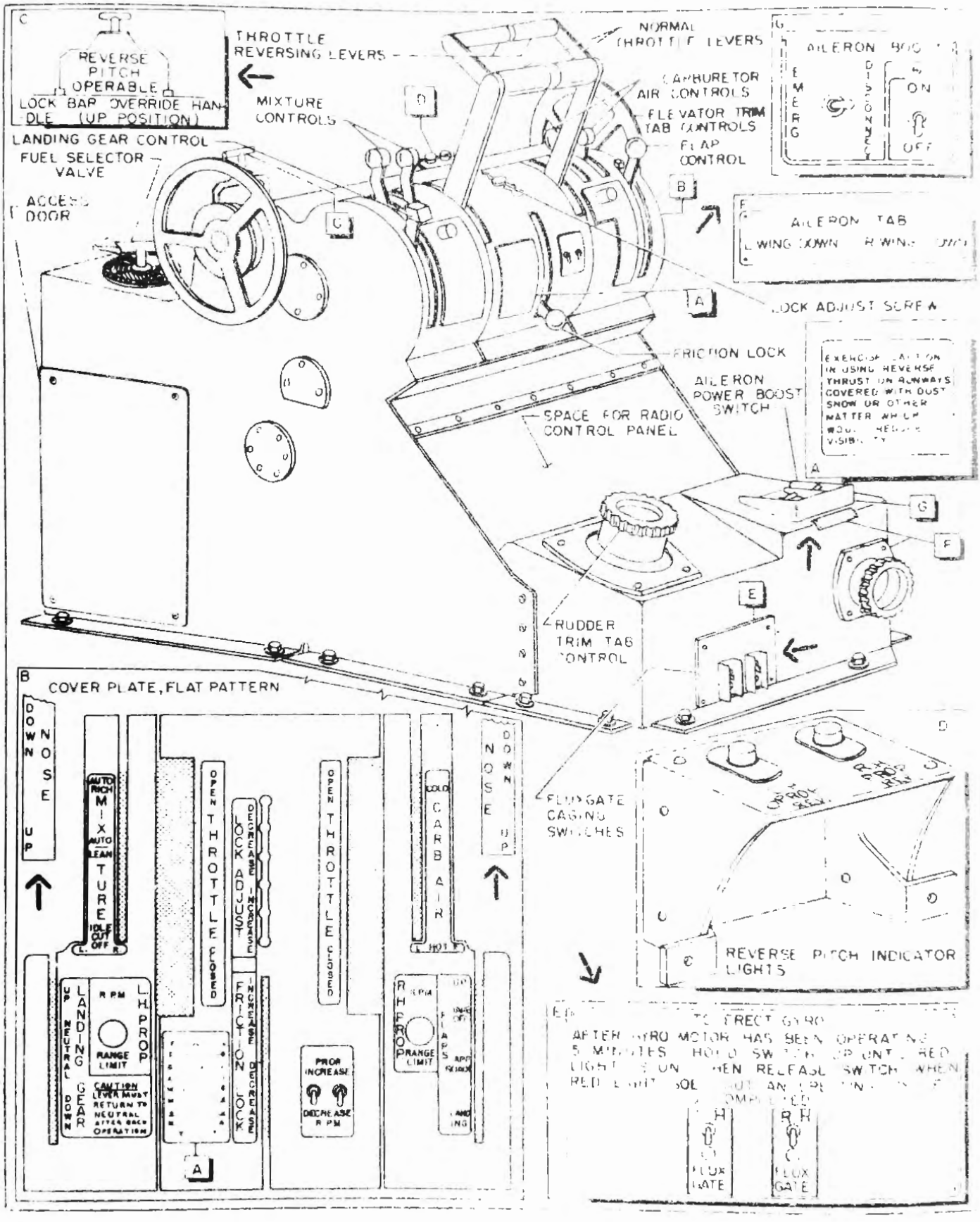


Figure 3. (Sheet 1 of 2 Sheets) Pilots' Pedestal


REVERSE PITCH OPERABLE
LOCK BAR OVERRIDE HANDLE (UP POSITION)
THROTTLE REVERSING LEVERS
NORMAL THROTTLE LEVERS
MIXTURE CONTROLS
CARBURETOR AIR CONTROLS
ELEVATOR TRIM TAB CONTROLS
FLAP CONTROL
LANDING GEAR CONTROL
FUEL SELECTOR VALVE
ACCESS DOOR
AILERON BOOST
EMERG DISCONNECT
ON
OFF
AILERON TAB
L WING DOWN
R WING DOWN
LOCK ADJUST SCREW
FRICTION LOCK
AILERON POWER BOOST SWITCH
SPACE FOR RADIO CONTROL PANEL
EXERCISE CAUTION IN USING REVERSE THRUST ON RUNWAYS COVERED WITH DUST SNOW OR OTHER MATTER WHICH WOULD REDUCE VISIBILITY
RUDDER TRIM TAB CONTROL
COVER PLATE, FLAT PATTERN
DOWN NOSE UP
AUTO RICH MIXTURE AUTO LEAN
IDLE CUT OFF
OPEN THROTTLE CLOSED
LOCK ADJUST
DECREASE INCREASE
FRICTION LOCK
INCREASE DECREASE
COLD CARBURETOR HOT
PROP INCREASE
DECREASE R.P.M.
UP NEUTRAL DOWN
LANDING GEAR
R.P.M.
RANGE LIMIT
LH PROP
CAUTION LEVER MUST RETURN TO NEUTRAL AFTER EACH OPERATION
RH PROP
FLAPS
APPROACH
LANDING
FLUXGATE CASING SWITCHES
REVERSE PITCH INDICATOR LIGHTS
GYRO
AFTER GYRO MOTOR HAS BEEN OPERATING 5 MINUTES HOLD SWITCH UP UNTIL RED LIGHT GOES ON THEN RELEASE SWITCH WHEN RED LIGHT GOES OUT AND GYRO IS COMPENSATED
L H FLUX GATE
R H FLUX GATE

GROUND RUN-UP PERFORMANCE LIMITS

BMEP (psi)	404
AMB. MAP	120
TAKE-OFF (Corrected) Min.	230
AUTO-FEATHERING	57-66
NO - AUTO FEATHERING ABOVE	85

RPM

AMB. MAP - 150 RPM MAX. SPREAD BETWEEN ENGINES	Approx. 2150
TAKE-OFF	2700+-25
TAKE-OFF WET	2800+-25
IDLE	550-650
AMB. MAP MAG. CHECK - RPM DROP NOT TO EXCEED 40 RPM BETWEEN MAGS.)	75
HIGH PITCH CHECK	1200-1400

MAP (in Hg.)

TAKE-OFF DRY	55
TAKE-OFF WET	59.5
BLOWER SHIFT - HI TO LOW - MAP DROP	1-2
IDLE - SPREAD BETWEEN ENGINES	2

OIL PRESSURE (psi)

ENGINE REAR (AMB. RUN)	85+-5 @ 85°C
ENGINE NOSE & REAR - IDLE	15 @ 85°C
ENGINE WARNING LIGHT "ON"	38-46
CABIN COMP. CAC - 1500 RPM, 404 - 1000 RPM	60-100
CABIN COMP., WARNING LIGHT "ON"	38-46

OIL TEMPERATURE (°C)

ENG. - BEFORE EXCEEDING 1200 RPM	40
CABIN COMP. BEFORE EXCEEDING 1000 RPM	7
ENG. OIL "IN" AT AMB, RUN-UP	85
CABIN COMP.	107

MISCELLANEOUS TEMPERATURE (°C)

CABIN COMP. BEARING AT 1500 RPM	150
CARB., AIR "HOT" - RISE AT 1500 RPM	15
CYL. HEAD - BEFORE AMB. RUN	120
CYL. HEAD	

FUEL PRESSURE (psi)

ENGINE DRIVEN PUMP - BOOST PUMPS OFF	21-23
BOOST PUMP "LOW" - ENGINE OFF	9.5
BOOST PUMP "HI" - ENGINE OFF - MCI LIMIT	19-26.5
BOOST PUMP "HI" - ENG. OFF - SVC. LIMIT	17.5-26.5
FUEL PRESSURE WARNING LIGHT	18-20

FUEL FLOW (lbs./hr.)

AT AMB. RUN-UP - NOT A LIMIT - GUIDE ONLY	550-630

MISCELLANEOUS LIMITS

HYD. PRESS. (psi) - 1200 RPM (Closed Center Sys.)	1225-1525
HYD. PRESS. (psi) - 1200 RPM (Open Center System)	300-3000
EMERGENCY BRAKE PRESS. (psi)	1250-1625
GENERATOR VOLTAGE - 1500 RPM	27.25-27.50
IDLE MIXTURE	BP @ 800 RPM
PROP PITCH THRU FULL RANGE (Sec.)	12
CABIN DIFF. PRESS IN HG.	6.5
WING FLAP - RETRACT OR EXTEND TIME (Sec.)	13
AMP. LOAD DIFF. BETWEEN GENERATOR	20
ADI PRESS. (Psi) AT AMB. RUN	24-26
ADI PRESS. (psi) 40-45 MAP	24-27
ADI LOW PRESS. WARNING LIGHT (psi)	18-20

OIL CAPACITY

Total Tank Capacity - 31.5 U.S. Gallons including 4.5 gallons expansion space

Service Capacity of Tank - 20.0 U.S. Gallons

Reserve - 2 Gallons (Propeller feathering oil

Dip Stick Graduation - 5 Gallon increments from 10 to 25 gallons

OIL COOLER FLAP ACTUATOR

Normal retracted length - 13 5/32 inches
Normal extended length - 18 5/32 inches
Normal stroke - 5 inches

OIL COOLER FLAP CLEARANCE

Closed Position - 5/8 - 1/8 inch (between Flap and Air Scoop)

SEQUENCE VALVE

Starts to open - 120°F (48.9°C)
Fully open - 158°F (70°C)

REGULATOR VALVE

Normal Thermostat setting - 165°F (73.9°C)

OIL GRADE

S.U.S. 100 or 120 at 210°F (98.9°C)

COWL FLAP TRAVEL

Closed = -6½° or 1"*
Normal = 0° or 2"*
Open = 30° or 7¼"*
*Measured from trailing edge of cowl flap to Accessory Cowl

IGNITION DISTRIBUTOR TIMING

Distributor timing right and left 20° - 21° (Table No. 1 in Series 11-22 is based on 20° - 21° timing)

VOLTAGE LIMITS AND AMPERAGE LIMITS

27.5 + 0-25 volts on each generator should be indicated and within 20 amps of each other.

VALVE CLEARANCE

Cold Clearance

Intake	.050 inch
Exhaust	.065 inch

TIMING CLEARANCE

Front Row Cylinders	Intake	.102 inch
	Exhaust	.127 inch
Rear Row Cylinders	Intake	.125 inch
	Exhaust	.143 inch

Specific Torque Recommendations for PWA Engines

The following torque values, all given in inch-pounds, are recommended by PWA for use during maintenance of the engine. These values are based on the use of parts which have no oil or special lubricant applied, except where maintenance instructions or these instructions specifically recommend a special lubricant or surface coat.

PART DESCRIPTION	TORQUE (Inch-pounds) Min.	Max.
CARBURETOR ATTACHING CAP SCREWS	200	225
Carburetor Fuel Transfer hose between attachment pad and Engine adapter pad. Cap screws	.50-75	

FUEL FEED VALVE DIAPHRAGM AND COVER RETAINING SCREWS

Tighten to 25 inch-pounds minimum and allow to set for 10 minutes; then re-tighten to 25 inch-pounds minimum.

EXHAUST COLLECTOR JOINT CLEARANCE

	Max.
Front exhaust port flange to extension pipe.	.040
Extension pipe sleeve to section Joint	.040

	TORQUE (Inch-pounds)	
Exhaust Collector ring section clamp rings bolts Torque 25-40 in. lbs.		
All 5/16 bolts and nuts 100-140 in. lbs. All 3/8 bolts and nuts 160-190 in. lbs.		
EXHAUST PIPE REAR FLANGE STUDS	100	140
EXHAUST PIPE VEE CLAMP BOLT	25	40
EXHAUST PORT STUDS	160	190
INTAKE PIPE VEE CLAMP BOLT	25	35
MAGNETO DRIVE GEAR NUT	100	125
OIL PRESSURE RELIEF VALVE SEAT	250	300
PRIMER COIL HOUSING NUT	20	30

EXHAUST COLLECTOR JOINT CLEARANCE (CONT.)

PROPELLER SHAFT THRUST BEARING COVER NUTS	200	250
PUSHROD COVER NUTS		
CYLINDER END	300	325
CRANKCASE END	80	90

REAR CASE ATTACHING NUTS

Long Studs - Tighten Nuts to approximately 50 inch-pounds; then finish tightening by turning each nut an additional 180 to 240 degrees.

Short Studs - The short stud in the intermediate rear case at the bottom of the oil scavenge passage and the short stud in the bottom of the rear case in front of the pressure oil strainer to 150 to 175 inch-pounds.

REAR SECTION SCAVENGE OIL STRAINER AND PLUG ASSEMBLY	300	400
ROCKER SHAFT NUTS	275	325
ROCKER BOX COVER NUTS	60	75
Rocker shaft caps	275-325 in. lbs.	
Distributor securing screws	55-65 in. lbs.	
Cover clamp screws	30-40 in. lbs	
Oil strainer coverplate Nuts	150-175 in. lbs.	
Oil Strainer Coverplate drain plug	300-400 in. lbs	
SPARK PLUGS	300	360

SPARKPLUG LEAD NUTS

Fingertight; then tighten an additional 15 degrees.

STARTER JAW NUT	325	375
VALVE ADJUSTING SCREW LOCKNUTS	300	350

Torquing of Cylinder Holddown Nuts (Stud Type Case)

Tighten cylinder flange nuts hand tight, then torque all nuts to 650 in. lbs; then loosen each nut individually to zero "o" and retorque to 650 in. lbs. The angle of turn required to tighten the nut from 50 in. lbs. to 650 in. lbs. must not exceed 90°. This torque applies to unplated nuts. Cadmium plated nuts may be used if the plating is sanded off of the seating surface. Use engine oil to lubricate the stud threads before installing the nuts.

Torquing of Cylinder Holddown Nuts (New Bolt Type Crankcase)

Tighten cylinder flange nuts hand tight, then torque all nuts to 575 in. lbs; then loosen each nut one at a time and retorque to 575 in. lbs. Use engine oil to lubricate the threads before installing the nuts. The angle of turn for the leg stud nuts must not exceed 90° from 50 to 575 in. lbs.

The angle of turn for the other (11) nuts must not exceed 130° from 50 to 575 in. lbs. A different feel is noticed between torquing of the studs and bolts. Greater elasticity of the new bolt is noticed. The four long bolts next to the leg studs may stretch one to two threads more than the other short bolts.

Cylinder Flange Attachment Studs (Old Type Crankcase),

If a cylinder flange attaching stud fails during engine operation, the adjacent studs, may be subject to severe overstress. The same is true if the nut becomes loose to the extent that there is clearance between the nut and cylinder flange. If more than two adjacent studs have broken or found loose, there is a possibility that the cylinder flange has been overstressed.

Engine Mount to Firewall Thru Bolts

1. Upper Bolt Torque 4000-5000 in . lbs.
2. Two lower Bolts 2000-2400 in. lbs.

Quick Engine Change Unit Fittings

1. Upper Fitting
   Fitting Mounting Bolts (4) 160-190 in. lbs.

2. Lower Fittings
   Fitting Mount Bolts (4) ea. 100-140 in. lbs.

3. Minimum Clearance Between Engine Mount and Fitting Mount Bolt - .005 in.

Torque Valves for Carburetor

Elastic Stop Nuts	Torque Inch-Lbs.
10-32	30-40
1/4-28	55-60
5/16-24	90-100
1/8 Pipe Plugs or Fittings	45-65

NOTE: Do not exceed 100 maximum torque when aligning fittings.

Cylinder Flange Attachment Studs (Old Type Crankcase

The following procedures are immediately effective.

If a nut has clearance with the flange or is found loose and/or the stud has failed the engine will be removed and returned to MCI for corrective action.

CAUTION: AN AIRPLANE MUST NOT BE RELEASED FOR FLIGHT WITH ANY BOLT OR STUD MISSING FROM ANY CLINDER FLANGE.

Cylinder Flange Attachment Bolts (New Type Crankcase)

If a cylinder flange attaching bolt fails during engine operation, the adjacent bolts or stud may be subject to severe overstress. The same is true if the nut becomes loose to the extent that there is clearance between the nut and cylinder flange. If more than two adjacent bolts have broken or found loose, there is a possibility that the flange has been overstressed.

With the new crankcase certain bolts can be replaced in the field. Refer to Section 11-35 for instruction.

Spark Plugs

The following spark plugs are approved for use in all positions of the R2800-CB-16:

AC271, RHB37N, RHA37N or R115
Barrel Color "Aluminum".

Firewall Shut-Off Valves - Leakage Limits

Firewall shut-off valves suspected of leaking internally (through the valve) or externally (around the valve shaft) shall have the down stream line removed and a leak check made as outlined below, before the valve is changed. The chart provides test pressure, permissible leakage and operating torques. Leak checks shall be made with the valve in the "CLOSED" position.

SYSTEM	VALVE MFGR.	TEST PRESSURE	PERMISSIBLE SERVICE INTERNAL LEAKAGE	PERMISSIBLE SERVICE EXTERNAL LEAKAGE	BREAK-AWAY AND *OPERATING TORQUES
Fuel	Hydro-Aire	Boost Pump Pressure	5 drops/min.	1 drop/hr.	Operating 35" lbs. max.
Oil	Hydro-Aire	Static	5 drops/min.	1 drop/hr.	Operating 35" lbs. max.
Hydraulic	Hydro-Aire	Static	5 drops/min.	1 drop/hr.	Operating 35" lbs. max.
A.D.I.	Parker	A.D.I. Pump On	5 drops/min.	1 drop/hr.	30# starting 20# operating

*Torque necessary to continue turning valve after break-away.

Oil Consumption Limits

Established of the limits and procedures outlined in this section is intended to assure safe and economical operation. Full compliance by maintenance personnel is essential.

NOTE: Oil consumption should be determined at 100 HP. Oil consumption determined at other HP's should be confirmed by rechecking at the above HP.

The maximum allowable oil consumption is 3 gallons per hour per engine.

Engine Overspeed Limits

Engine overspeed limits are divided into three categories. Handling of engines which have overspeeded shall be in accordance with the procedure established for the applicable category.

Engine Overspeed Limits and Category Classification

A. Category I - 2880-2900 RPM - Requires special maintenance.
B. Category II - 2901-3100 RPM - Requires special maintenance.
C. Category III - Above 3100 RPM - Requires engine change.

NOTE: Overspeed to 2880 RPM is considered routine and may be corrected by governor adjustment.

Special Maintenance for Engines Which Have Overspeeded

Category I

1. Replace governor

   NOTE: Particularly, check governor gasket for metal particles. Presence of metal indicates a possible engine failure. Check further as necessary to determine whether engine failure does exist.

2. Conduct an engine run-up and check operation of governor.

Category II

1. Conduct a "wheeze" check.
2. Check sumps and magnetic plugs for indication of material failure.
3. Check all cylinder holddown nuts for looseness and loss of palnuts. (Visual check)

Special Maintenance for Engines Which Have overspeeded Cont'

3. Replace governor.

NOTE Particularly check governor gasket for metal particles. Presence of metal indicates a possible engine failure. Check further as necessary to determine whether engine failure does exist.

4. Conduct a thorough run up of the engine and check operation of the governor.

5. If engine is found normal, forward message to next terminating station requesting check of sumps and magnetic plugs, stating reason

Category III

1. Change engine.

Valve Failure - Procedure

An intake valve failure requires that the engine be removed and sent to the Overhaul Base for repairs because it is impractical to disassemble the engine in the field, to the extent necessary to assure that all contamination has been removed from the induction system.

GROUP POWER PLANT AND WATER INJECTION

SECTION CARBURETOR IDLE ADJUSTMENT

PAGE NO. 1

DATE 5-10-57

When a carburetor is once set for proper idling, it does not ordinarily require adjustment except to correct it for wide variations of weather conditions. An idling adjustment should not be changed until all other possible causes of unsatisfactory idling have been investigated. All idling checks should be made in relatively still air or with airplane cross wind. A strong wind effects propeller loading and the rpm change may be different from that noted below.

Idle Mixture

Adjustment Procedure (See Figure on Page 2)	Special Instructions
1. Warm up engine at 1000 rpm.	1. Desired temperatures: Oil - 60 to 70 C Cylinder Head - 150 C
2. At ambient MAP, check spark plugs and mags by operating on each mag separately.	2. Maximum drop-off when switching to one mag is 75 rpm. Difference in drop between "R" and "L" should not exceed 40 rpm. Correct excessive drop before proceeding.
3. Set throttle to 800 rpm.	3. Keep rpm at 800 throughout procedure by changing throttle as necessary, except after each adjustment is made, clear engine at 2000 rpm before proceeding.
4. Move mixture control to "IDLE-CUT-OFF" observing for rise in rpm. Return control to "Auto-Rich" before engine stops.	4. A rise before drop off indicates rich mixture.
5. If no rise in rpm is obtained in step 4, skip to step 8.	
6. If rise in rpm is obtained in step 4, lean the mixture by turning the knurled adjusting screw (Figure on Page 2) one or two notches in a counter clockwise direction.	6. If adjusting range of screw unsatisfactory accomplish step 12 before proceeding.
7. Repeat steps 4 and 6 until no rise in rpm is obtained.	
8. Momentarily apply primer, observing for rise in rpm.	8. A rise in rpm indicates a lean mixture.
9. If no rise is obtained in step 8 (assuming steps 4 through 7 to have been satisfactorily completed) idle mixute is indicated to be satisfactory. Skip to step 13.	
10. If rise in rpm is obtained in step 8, enrithen the mixture by turning the knurled adjusting screw (See Figure on page 2) one or two notches in a clockwise direction.	10. If adjusting range of screw unsatisfactory, accomplish step 12 before proceeding.
11. Repeat steps 8 and 10 until no rise is obtained.	
12. If proper mixture setting cannot be obtained within range of adjustment screw, lengthen or shorten the idle lever screw assembly as follows:	12. Accomplish only if required. If this step is accomplished it will be necessary to start procedure over with step 4.
a. Remove link bolt, four plain washers, wave washer and bushing as shown in detail A.	
b. Turn the idle lever screw assembly into the threaded bushing if a leaner mixture is desired.	

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Adjustment Procedure (Cont.)

12. (Cont.)

    c. When reconnecting linkage, be sure that the plain washers, wave washer and bushing are assembled as shown in detail A.

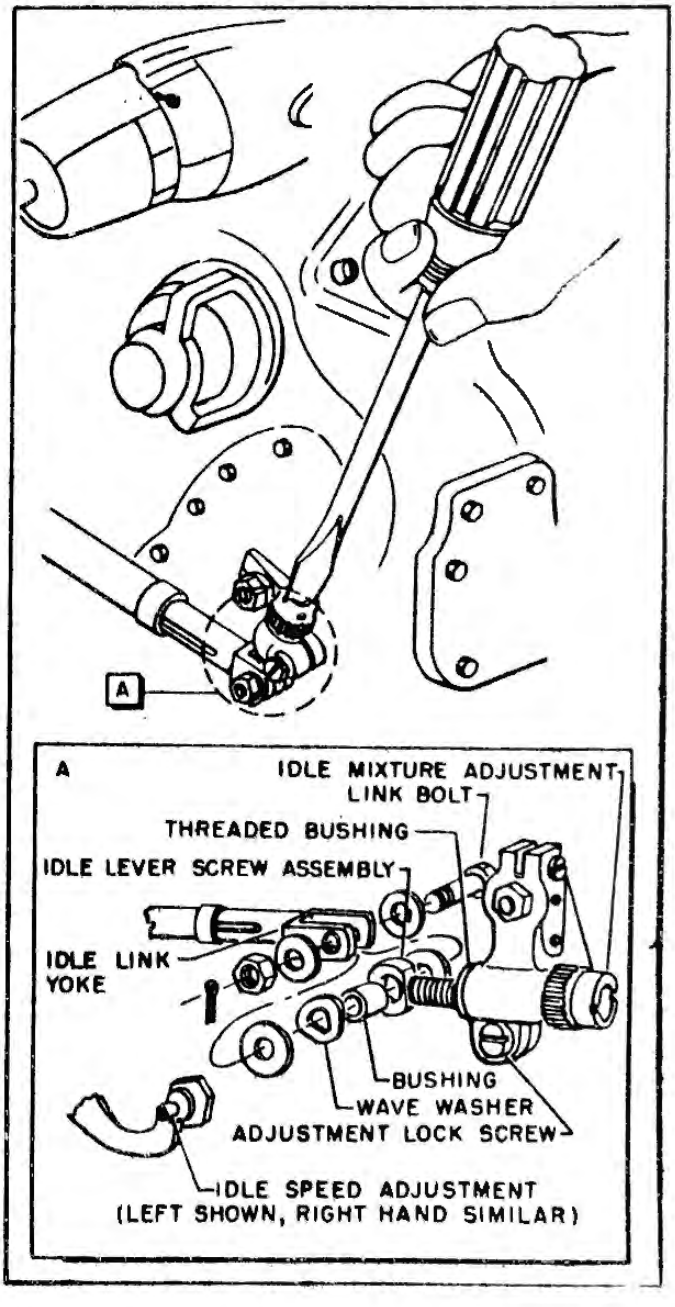
    d. The nut on the link bolt must be tightened enough to allow the idle link yoke and plain washers to clamp the bushing so it cannot move on the bolt. Install cotter pin in castellated nut.

13. Adjust retarded throttle stops to 600 +/- 50 rpm.

14. After completion of idling adjustment, tighten and safety idle mixture adjustment lock screw.

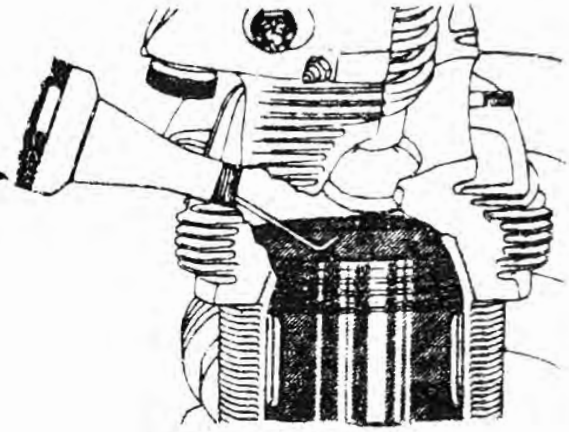
Special Instructions

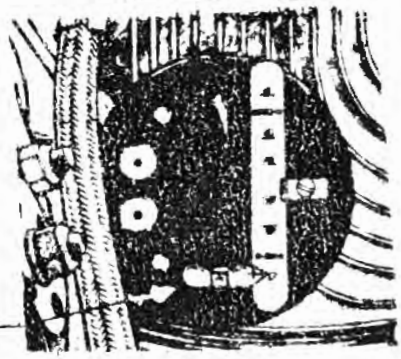
13. Adjust with left throttle stop. After adjustment set right throttle stop to just touch throttle arm.



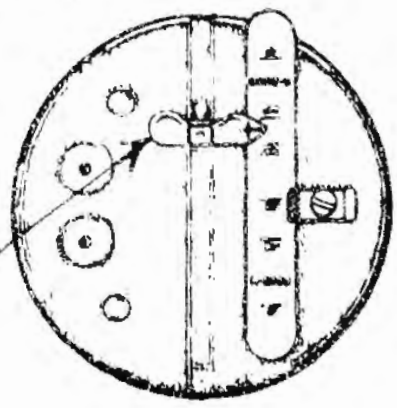
Special Tools: Time Rite Indicator, Timing Light

Procedure	Special Instructions
1. Determine that the ignition system is grounded.	
2. Remove front spark plug from No. 1 cylinder and remove distributor cover.	
3. Position No. 1 piston 21° before top center of the compression stroke as follows:	
a. Turn engine in direction of rotation until No. 1 piston starts up on compression stroke.	a. Do not bring piston too close to top center.
b. Screw Time Rite Indicator (using 1-209-1 scale and arm A) into front plug position of No. 1 cylinder.	
c. Rotate Time Rite cap until the slot is approximately vertical and degree scale is on the right side. Push sliding pointer to top of slot.	
d. Turn engine in direction of rotation until piston goes through top center and starts down.	

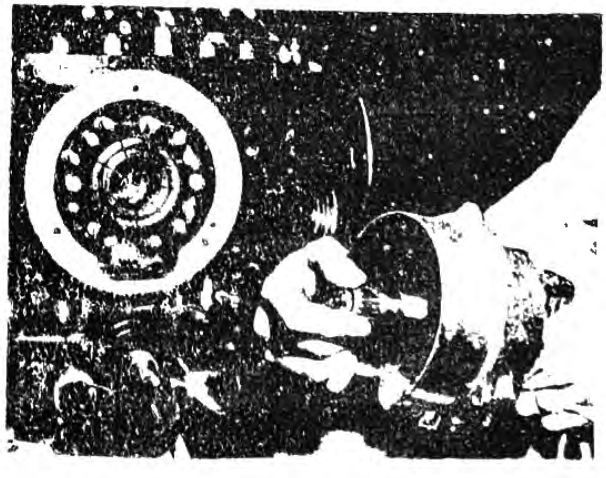




e. Without moving the slide pointer, position the degree scale until "0" degrees aligns with the reference line of the sliding pointer.	e. Do not disturb degree scale after having once aligned it.
f. Turn engine opposite normal direction of rotation, through top center, stopping approximately 1/8 turn past the 21° BTC timing position.	
g. Position sliding pointer to the top of slot against pivot arm.	



Procedure (Cont.)	Special Instructions
h. Turn engine in normal direction of rotation until Time Rite Pointer aligns with 21°.	h. This is the position at which the No. 1 breaker points of the distributor and magneto "E gap" are timed to. Do not turn engine until distributor is installed.
4. Disconnect primary leads from segment plate of distributor.	4. These can be identified by tracing condenser leads of the distributor to their respective terminals on the distributor segment ring and removing the other lead at each of these points leaving the condenser leads hooked up.
5. Remove the three screws securing the distributor to its base and lift distributor off mounting pad.	5. Exercise care so the carbon sealing ring of the oil seal is not damaged.
6. Check mating surfaces of distributor and base for being clean.	
7. Check segment plate for burned spots.	7. A segment plate that shows definite burned spots is to be replaced. A definite burned spot is defined as one with a ridge that can be felt when the finger nail is passed over the segment in line with brush travel.
8. Line up step on distributor shaft with No. 1 timing post mark.	8. No. 1 points should just open at this point.
a. Install distributor on its base and secure with the three securing screws.	a. Exercise care so the carbon sealing ring of the oil seal is not damaged.
9. Turn engine opposite direction of rotation, move slide pointer of Time Rite up and connect light to No. 1 breaker points.	
10. Turn engine in direction of rotation, and with back-lash held out, note degrees on Time Rite indicator when No. 1 points open.	10. Hold out backlash of distributor drive train with a 7/8" end wrench on the large nut at the top of the distributor. Hold wrench against normal rotation with a firm pressure of about 40 inch pounds.
11. Time Rite pointer must be between 20°-21° at time No. 1 points open. If not, distributor will require retiming to the engine as follows.	
12. Note number of engine degrees distributor is out of time.	12. Given by Time Rite.
13. Remove distributor, and pull cotter key from nut at drive end of the distributor shaft. Loosen nut 1 1/2 turns and turn spline end the exact number of clicks given in chart.	
EXAMPLE: Time Rite indicated distributor was timed to 16°. Find 16° on chart and read across for the number of clicks required to bring timing back to 20° - 21°. Viewing distributor from drive end, 4 clicks to the left and 1 click to the right will be required.	



Procedure (Cont.) Special Instructions

TABLE 1 - RATCHET SETTINGS

	Firing Position Engine Crankshaft Degrees	CLICKS TO MOVE RATCHETS Left Anti-Clw. Viewing Drive End. Distr.	Right Clw. Viewing Drive End Distr.
LATE	11-12	3	8
LATE	12-13	8	2
F	13-14	13	19
I	14-15	18	13
R	15-16	23	7
I	16-17	4	1
N	17-18	9	18
G	18-19	14	12
	19-20	19	6
DESIRED	20-21	0	0
EARLY	21-22	5	17
F	22-23	10	11
I	23-24	15	5
R	24-25	20	22
I	25-26	1	16
N	26-27	6	10
G	27-28	11	4

14. Recheck timing by first tightening the spline nut wrench tight, then install distributor minus the hold-down screw and check as in Steps 9, 10 and 11. If OK, install cotter key through spline nut, secure distributor and safety wire securing screws. Install primary leads from segment plate to distributor. Install distributor cover and secure with clamp.

14. Torque distributor securing screws to 55-65 inch pounds and cover clamp screw to 30-40 inch pounds.

Special Tools - Time Rite Indicator, Timing Light

Procedure

Special Instructions

1. Determine that ignition system is grounded.

2. Remove front spark plug from No. 1 cylinder.

3. Position No. 1 piston 21° before top center on the compression stroke as follows:

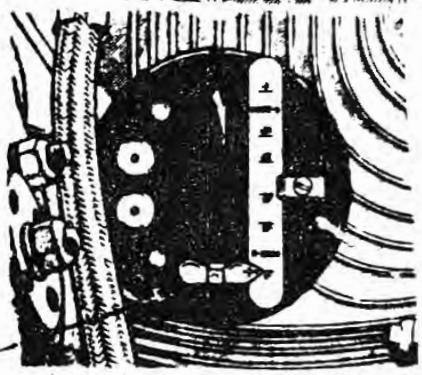
   a. Turn engine in direction of rotation until No. 1 piston starts up on compression stroke.

   a. Do not bring piston too close to top center.

   b. Screw Time-Rite indicator (using 1-209-1 scale and arm A) into front plug position of No. 1 cylinder.

   c. Rotate Time-Rite cap until the slot is approximately vertical and degree scale is on the right side. Push sliding pointer to top of slot.

   d. Turn engine in direction of rotation until piston goes through top center and starts down.

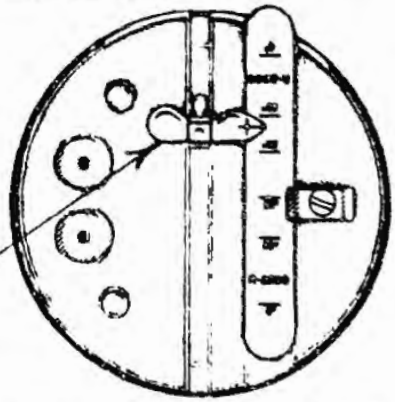


   e. Without moving the slide pointer, position the degree scale until "0" degrees aligns with the reference line of the sliding pointer.

   e. Do not disturb degree scale after having once aligned it.

   f. Turn engine opposite normal direction of rotation, through top center, stopping approximately 1/8 turn past the 21° BTC timing position.

   g. Position sliding pointer to the top of slot against pivot arm.



   h. Turn engine in normal direction of rotation until Time-Rite pointer aligns with 21°.

   h. This is the position the magneto "E gap" is timed to. Do not turn engine until magneto is installed.

Procedure (Cont.)

Special Instructions

4. Detach magneto lead from the ignition manifold.

5. Remove four magneto attaching screws and washers.

6. Remove magneto from engine.

7. Clean engine mounting flange and check flange of magneto to be installed for being clean.

8. Install magneto as follows:

a. Press the plunger in and turn the magneto shaft until the plunger engages one of the notches in the shaft, thereby locating the magneto near its firing position.

a. Plunger is located near the base of the magneto. The plunger is to be used only during magneto installation for holding the rotor in a preliminary timing position.

b. While still holding the plunger engaged with the notch in the shaft, place the magneto on the engine, engaging the drive spline with the mating engine part in such a relation that the magneto attaching screws will be approximately centered in the elongated slots in the magneto mounting flange.

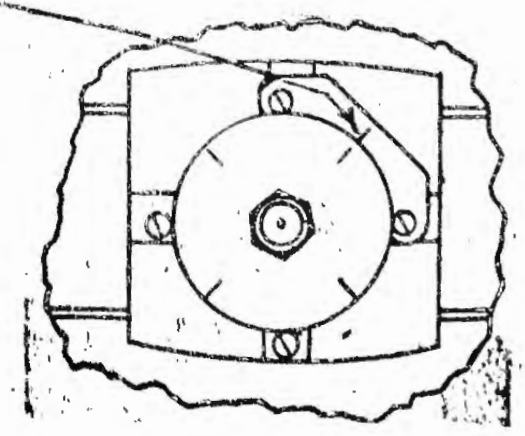
b. If the magneto cannot be installed in this relation, remove it and turn magneto shaft 90 degrees until timing plunger engages in the next notch in the shaft. Reinstall magneto on engine.

c. Install magneto attach screws and washers.

c. Do not tighten screws.

9. Rotate the magneto housing until the mark on the timing disc is aligned with the reference index.

9. Marks may be seen through the viewing window in the top of the magneto cover.



a. Tighten the securing screws and recheck timing to the engine.

10. Connect the magneto outlet conduit to the magneto connector of the ignition manifold.

11. Lockwire all attaching screws and the electrical connector.

Personnel operating engines installed in an airplane shall be qualified as specified in Technical Services General Policies and Procedures Manual.

There shall be one qualified TWA employee at the captain's station who shall perform the run-up and be in charge of the aircraft. He must accomplish the "Before Starting Engines", "After Starting Engines" and "Secure Cockpit", cockpit check list and remain alert for movement of the aircraft being run and for movement of any object on the ground which might endanger the aircraft. He shall maintain radio contact with the tower, if necessary.

There shall be one qualified employee on the ground to give clearance for starting engines and to act as fire guard. He shall be responsible for.

1. Determining that wheel chocks have been positioned at the front and rear of each outboard main landing gear wheel.

2. Clearing equipment away from all affected areas.

Taxiing of an aircraft will be accomplished with a minimum of two qualified TWA employees in the cockpit; one at the captain's station and one at the first officer's station.

The following procedure shall be followed at any time the Martin 404 primary compressor is drained, or removed and installed, unless pressure pre-oiling equipment is available and it can be, or has been pre-oiled with this equipment.

Prior to the initial warm-up, or run up of the engine, the primary compressor will be connected and then disconnected as soon as the engine is started; after which time the engine will receive a complete warm-up or Op. 5 run up, whichever the case may be and shut-down. Immediately after shut-down, the primary compressor will be reconnected and pre-oiled as outlined in Chapter 17.

NOTE: Whenever operating the right engine with the primary compressor connected, it is necessary to have the air flow selector set on "AUX. VENT" and one ventilating fan turned "ON".

It is the supervisor's responsibility to ascertain that only qualified employees participate in engine run-ups.

Preparation for Engine Run-Up	Special Instructions
1. Nose airplane into the wind if possible.	
2. Chock main gear wheels, fore and aft.	
3. Check installation of each landing gear safety pin and install if not in place.	3. Installed through hole in each gear jury strut, just below down lock.
4. Inflate shock struts.	4. Main gear approximately 5" and nose gear 7 1/4", for correct inflation. (Refer to charts in Chapter 15, for temperature pressure curves.
5. Connect nose torsion link.	5. Located on rear of nose shock strut above wheel.
6. Remove pitot covers.	6. Located on rear of nose shock strut above wheel.
7. Fuel quantity for run-up. (Min. 50 gals.)	7. Quantity gauge located on outboard side of each nacelle.
8. Oil quantity. (Minimum 10 gallons)	8. Check with dip stick in each oil tank filler neck, located on upper left side of each nacelle.
9. Determine that primary compressor is connected.	9. Located on upper left side of primary compressor, which is mounted on the left side of the right engine accessory case.

Preparation for Engine Run-Up (Cont.)	Special Instructions
10. Check primary compressor oil supply. (1-3/4 gallons)	10. Tank located forward if firewall on right side of the right engine. Check with dip stick on filler cap.
11. Check secondary compressor oil supply. (3 pints).	11. Crankcase oil sump dip stick located between the secondary compressor and expansion turbine, which is in hatch #70 (first hatch rear of nose wheel well) on right side.
12. Anti-icer tank quantity. (15 gals. cap.)	12. Tank located in aft end of right wing fillet (top and bottom filler). Liquidometer in cockpit is the only way of telling the quantity.
13. Fill ADI tank full. (15 gal.)	13. Tank located in aft end of left wing fillet (top and bottom filler.) Liquidometer in cockpit on pilot's forward instrument panel.
14. Close all inspection doors and access covers.	
15. Clear all equipment from front and rear of ship.	
16. Check plane's battery for installation and connection and battery circuit breaker "ON".	16. Located in electrical hatch #74 (fourth hatch aft of nose gear wheel well).
17. Connect auxiliary ground power.	17. Obtain motor generator for auxiliary power and connect in receptacle, to right and aft of electrical hatch. Engage external power circuit breaker located by receptacle.
18. Hydraulic fluid quantity. (5½ gallons).	18. Sight gauge on aft end of tank located on left aft side of 212 bulkhead. Fill to top of filler neck when "0" psi hydraulic pressure is indicated on closed center pressure gauge.
19. Obtain and fill out an engine run-up sheet.	

NOTE: If a cabin pressurization check is required during run-up, it will be necessary to place airflow selector to pressurized flight and turn off the cabin temp. circuit breaker located on the forward distribution panel (aft left side of 212 bulkhead) and manually operate "H" valve by TO HEAT POSITION inserting "T" handle through hole in companionway (cabin to cockpit) floor.

Pre-Starting Check Procedure	
1. Read and accomplish the "Before Starting" check list.	1. Never start engines until this is accomplished.
2. Turn circuit breakers "ON".	2. Located on both sides (front and rear) of 212 bulkhead, above hydraulic reservoir and below radio rack.
3. Turn battery switch to "EXTERNAL POWER".	3. Located in green section of overhead electrical panel.
4. Generator switches "OFF".	4. Located next to the above.
5. Turn inverter switch on, then check "East" and "West" inverter with selector and leave in the latter position.	5. Located on right side of green section on overhead electrical panel (selector switch directly below.)

Pre-Starting Check Procedure (Cont.)	Special Instructions
6. Monitored bus switch "ON".	6. Located just outboard of the above.
7. No. 1 DC load switch "ON".	7. Located just outboard of the above.
8. Radio DC switches and 115V AC phase circuit breakers "OFF".	8. Located in green section of overhead electrical panel and power panel on radio rack.
9. Cowl flaps "OPEN".	9. Switches located in blue section of overhead electrical panel.
10. Engine superchargers "LOW".	10. Switches on overhead electrical panel located directly below the above.
11. Ignition switches "OFF".	11. Located in center of overhead electrical panel.
12. Water injection (ADI) switch "OFF".	12. Located in lower left corner of blue section on overhead electrical panel.
13. Oil cooler flap "OPEN".	13. Switches located above ADI switch.
14. Auto propeller feathering switch "OFF".	14. Located in lower center position of overhead electrical panel.
15. Airflow selector switch "AUX VENT" (If cabin is not to be pressurized).	15. Located on right side of overhead electrical panel.
16. Turn off all electrical switches not required for run-up.	16. Such as ventilating fans, landing lights, passing light, etc.
17. Test fire detector warning lights.	17. Located in upper center position of overhead electrical panel.
18. Emergency fluid shut-off valves "OPEN".	18. Open when Zone 2 fire pulls are pushed in (located under glare shield).
19. Fuel tank selector valves "NORMAL ON".	19. Located on the forward corners of control pedestal.
20. Mixture control "IDLE CUT-OFF".	20. Located on left side of pedestal.
21. Throttles "CLOSED".	21. Located on control pedestal.
22. Hold propeller governor switches to "INCREASE RPM" until indicator light glows.	22. Switches located aft of throttle levers. Indicator lights next to the switches.
23. Carburetor air "COLD".	23. Located on right side of control pedestal.
24. Wing flap control "UP".	24. Located next to the above.
25. Landing gear control handle "NEUTRAL".	25. Located on left side of control pedestal.
26. Hydraulic by-pass valve "CLOSED".	26. Located left of pilot's feet.
27. Park brakes.	27. Before parking brakes, have a minimum pressure of 1000 psi indicated on the closed center system pressure gauge (located on lower left corner of co-pilot's instrument panel). When insufficient pressure is observed, it can be built up by first positioning "Emergency pump selector valve" to "ALT. POWER" (located in the floor to the right of co-pilot's chair) and then energizing auxiliary hydraulic pump (switch located on pilot's console below nose steering wheel).

Pre-Starting Check Procedure (Cont)	Special Instructions
28. Place primary compressor power switch in "LOW".	28. Located on upper corner of co-pilot's console.
29. Place ground test switch in "NORMAL".	29. Located on lower left corner of co-pilot's console.
30. Place ground test switch in "NORMAL".	30. Located on lower left corner of co-pilot's console.
31. Turn all anti-icing heater switches "OFF".	31. Located aft of co-pilot's console on wall.
32. Placeemergency pump selector valve to "NORMAL".	32. Control handle on floor to the right of ;the co-pilot's chair.
33. Move emergency wing flap selector to the NEUTRAL" position.	33. Located forward of the above.

Starting Engines	Special Instructions
1. Fire guard posted.	1. Mechanic standing by with one (1) 100# fire extinguisher to give clear signal.
2. Turn props through with starter - minimum of eleven (11) blades.	2. Starter and selector switches located in center of blue section on overhead electrical panel. a. Purpose to check for liquid lock (1) When starter is engaged and prop stops suddenly, as if hitting something a liquid lock is present. (2) When encountered, it will be necessary to remove the front plugs on the lower cylinders, letting the trapped liquid drain out - after which replace plugs and turn propeller through again.
3. Turn right fuel booster pump "ON".	3. Switch in upper left corner of blue section on overhead electrical panel
4. Set right throttle approximately 1" from closed position.	
5. Turn right ignition switch "ON".	
6. Hold starter selector switch to right engine.	6. Switch in center of overhead electrical panel.
7. Energize starter. When engine starts turning, depress primer and hold until engine fires - then prime intermittently.	7. Switches above the selector switch If engine fails to start after one (1) minute of cranking, stop and allow starter to cool one (1) minute.
8. Move mixture control slowly to auto-rich. Discontinue priming and dis-engage starter.	8. A cold engine may require intermittent additional priming.

Starting Engines (Cont.)

	Special Instructions
9. Operate engine at 800 rpm and observe engine oil pressure.	9. Oil pressure gauge located on center instrument panel. If no indication in 30 seconds stop engine and investigate cause.
10. Observe primary compressor oil pressure.	10. Oil pressure gauge located on co-pilot's console. If pressure does not exceed 25 psi in 15 seconds stop engine and investigate cause.
11. Observe "I" and "D" pointers on primary compressor manifold pressure gauge.	11. Gauge located on co-pilot's console. If reading is erratic ("I" should drop 1" Hg. or less and "D" should increase from 1 to 20" Hg depending upon position of H valve) stop engine immediately and investigate for a restricted duct. (30 seconds running will damage the compressor).
NOTE: If the primary compressor has not been pre-oiled, disconnect after 30 seconds of operation. (See Chapter 17 for pre-oiling procedure).	NOTE: Disconnect switch on upper left corner of co-pilot's console. Never disconnect unless engine is running.
12. Advance throttle to 1000 rpm.	12. CAUTION: Do not exceed 1000 rpm with right engine until primary compressor oil temperature is at least 7°C. (Disregard this if compressor was disconnected.)
13. Turn "OFF" right fuel boost pump.	
14. Turn on at least one ventilating fan. (Disregard if compressor was disconnected).	14. Switch located on right side of overhead electrical panel. CAUTION: Must always be on when running right engine if compressor is connected; otherwise damage may result to the expansion turbine from overheating.
15. Check wing flap operation and closed center system hydraulid pressure.	15. This will also be checked with the opposite engine on shut-down.
a. Relieve pressure on closed center system hydraulic pressure gauge by operating wing flaps until pressure drops to 1250 for ~25 psi where regulator should cut in.	a. A dual indicating pressure gauge is mounted on the lower portion of the co-pilot's instrument panel; the "I" hand indicates closed center pressure.
b. Observe gauge; pressure should build up rapidly to 1500 psi if pump on this engine is OK.	
c. Observe wing flap position indicator for properly indicating position selected.	c. Located on lower portion of center instrument panel.
16. Repeat Items 3 through 13 with the left engine omitting Items 10 and 11.	
17. Have standby mechanic remove ground power after both engines are started.	

18. Turn battery selector switch to "PLANES'S BATTERY" position.

During Warm-Up	Special Instructions
1. Set throttles to 1000 RPM for warm-up.	1. Warm-up until cylinder head temperature reaches a minimum of 120°C and oil temperature 60°C.
2. Turn generator switches "ON" and check voltmeter and ammeter for generator operating properly.	2. Voltmeter and ammeters located on pilot's console. (For this step, it may be necessary to momentarily advance RPM to 1200)
3. Press on panel to determine if "TURN AND BANK", "ARTIFICIAL HORIZONS" and "DIRECTIONAL GYRO" respond to the panel movement.	3. Located on pilot's and co-pilot's instrument panels. Instruments are electrically operated. Be certain inverter or alternators are turned "ON".
4. Check crossfeed operation.	
a. Turn left engine selector to "OFF" until fuel pressure drops, then turn back to "NORMAL ON".	
b. Turn right fuel selector to "RH TANK TO RH ENGINE AND CROSSFEED".	
c. Turn left fuel selector to "CROSSFEED TO LH ENGINE".	c. Allow engine to run in this position approximately two (2) minutes.
5. Repeat Item #4 with opposite engine. When completed, turn both engine fuel selectors back to "NORMAL ON".	
6. Idle both engines (700 RPM) and check for magneto ground with ignition switches.	
a. Turn left engine ignition switch to "OFF" position.	a. Engine RPM should drop immediately.
b. Turn switch back to "BOTH".	
c. Repeat with opposite engine.	
NOTE: Avoid continuous engine speeds of 1100 to 1200 RPM and 800 to 900 RPM with the right engine, as these are the ranges in which compressor shifts occur, thus causing excessive wear on the mechanism. (Disregard if compressor was disconnected.)	
7. Advance throttles to 1700 RPM.	
8. Check propeller governor operation.	
a. Run propeller from low to high several times, by moving control switch from increase to decrease RPM and vice-versa.	a. This will fill dome with warm oil.
b. Move propeller control switches to decrease RPM or high pitch.	b. RPM should drop 1300 ± 100.
c. Return propeller control switches to increase RPM or low pitch.	
9. Check auto feather operation.	
a. Advance both throttles to 1900 ± 50 RPM.	

9. Cont.		Special Instructions
	b. Turn on auto feather switch (Observe if "Red" power light comes on.)	b. Switch located in lower center position of overhead electrical panel.
	c. Turn on guarded momentary test switch for each propeller. (Amber arming light should be on but propeller should not feather).	c. Switches are located in lower center position of overhead electrical panel.
	d. Reduce left throttle to approximately 1400 RPM.	
	e. Turn left test switch on (observe if left "Red" feathering button light comes on and that engine RPM drops.	e. Immediately release test switch and pull out on manual feathering button to stop featnering action.
	f. Return left throttle to 1900 RPM.	
	g. Reduce right throttle to approximately 1400 RPM.	
	h. Turn right test switch to on. (Observe if right "Red" feathering button light comes on and that engine RPM drops.	h. Immediately release test switch and pull out on manual feathering button to stop feathering action. Check to see that primary compressor did not disconnect during this operation.
	i. Return right throttle to 1700 RPM.	
	j. Reduce left throttle to 1700 RPM.	
	k. Turn off auto-feather switch.	
10. Check manual feathering operation.		
	a. Move left propeller control switch to decrease RPM or high pitch (1200 RPM).	
	b. Depress feathering button.	b. Hold in.
	c. Pull out to neutral position as soon as decrease is noted (RPM should return to 1300)	c. Pull out to unfeathered position to de-energize auto-feathering remembering relays, after RPM returns to 1300.
	d. Repeat Item 9, a, b, and c for opposite engine.	
Run-Up		
1. Advance right throttle to 1700 RPM.		1. Operate left engine at approximately 1000 RPM while making run-up on right.
2. Turn "ON" ADI switch (placarded "WATER INJECTION").		2. ADI pressure gauge (placarded "WATER PRESSURE") located on center instrument panel, should indicate 24 - 26 psi.
3. Move right supercharger control switch to "HIGH BLOWER".		3. Manifold pressure should rise approximately ½".
4. Advance right throttle to manifold pressure. Equivalent to station barometric pressure.		4. Do not exceed 232°C cylinder head temperature at anytime when operating engines.
	a. Move right supercharger control switch to "LOW BLOWER".	a. Manifold pressure should drop 2" Hg. 1" Hg. minimum.
	b. Record RPM indication.	b. Should be 2150 RPM +/- 50 RPM.

		Special Instructions
(Cont.		
nt.)		
	Record oil pressure indication.	c. Should be 80 - 90 psi.
	Record oil temperature indication.	d. Should be 70°C.
	Record BMEP indication.	e. Should be 120.
	Record fuel pressure indication.	f. Should be 22 psi ± 1 psi.
	Record fuel flow indication (disregard if instrument not yet installed).	g. Should be 550 to 630 lbs. per hour.
	Make a magneto check.	
	1. Turn ignition switch from "BOTH" to "LEFT" then to "BOTH" then to "RIGHT" and back to "BOTH"	
	2. Observe RPM drop on tachometer while checking switches.	2. Normal drop 40 - 75 RPM maximum if not rough.
1.	Record cylinder head temperature.	1. Instrument located on center panel.
5.	Check ADI flow indication and autofeathering arming light.	5. At approximately 40 to 45" Hg. Manifold pressure ADI flow will be indicated by a drop in pressure of approximately 2 to 3.
6.	Advance throttle to 59.5" Hg. manifold pressure (maximum when required.)	6. Do not pull maximum except when necessary.
7.	Record RPM indication.	7. Should be 2800 RPM.
8.	Retard throttle until oil pressure low light comes on and record same.	8. Should come on at 47 ± 5 psi. It may be necessary to move mixture control to idle cut-off momentarily in order to get an oil pressure warning light. (After first Op. 5 this will be changed to 42 ± 5 psi).
9.	Turn off ADI and auto-feathering switches.	
10.	Close throttle (idle position).	
11.	Record idle RPM.	11. Should be 600 ± 50 RPM.
12.	Check idle mixture.	
	a. Advance throttle to 800 RPM.	
	b. Move "MIXTURE" control from "AUTO-RICH" to "IDLE CUT-OFF".	b. With a properly set mixture, engine RPM should fall off at once.
	c. Move "MIXTURE" to "AUTO-RICH" then record indication.	
	d. Momentarily apply primer.	d. With a properly set mixture, engine RPM should fall off at once.
	e. If idle mixture fails to check properly, refer to series 11-7, page 1.	
	Observe and record when fuel pressure low light comes on.	13. Should be 17 ± 0.5 - 0 psi. It may be necessary to move mixture control to idle cut-off momentarily, in order to get a fuel pressure warning light. (After first Op. 5 this will be changed to 19 ± 1 psi.

Run-Up (Cont.)

	Special Instructions
14. Record idle fuel pressure.	14. Should not be less than 14 psi.
15. Advance throttle to 1000 RPM. Observe and record when primary compressor oil pressure indication (disregard if compressor was disconnected).	15. Do not exceed 1000 RPM as compressor will shift into low. Should be 80 ± 20 psi.
16. Record primary compressor oil temperature. (Disregard if compressor was disconnected.)	16. Should not exceed 107°C.
17. Repeat items 1 through 15 with the left engine.	
18. Advance throttle to 1500 RPM.	
19. Check carburetor air operation.	
a. Move carburetor air control from "COLD" to "HOT".	
b. Observe and record indication.	→ b. Should indicate a rise in temperature. Do not exceed specified value.
c. Move control to "COLD" position.	
d. Repeat above with opposite engine.	
20. Apply a generator load of 200 amps. between generators. See "Generator Capacity" under "Maintenance Notes" in Chapter 24 for maximum continuous operating loads.	20. Turn on landing lights, radio, etc., to obtain this load.
a. Observe and record volt and ammeter indication.	a. 27.5 ± 0 - .25 volts on each generator should be indicated and within 20 amps of each other.
21. Check engine alternator operation on each engine.	
a. Turn "OFF" inverter.	a. Power failure indicators on both pilot and co-pilot's instrument panel should turn "WHITE".
b. Turn switch below each respective indicator to "ON" and observe AC power failure indicator.	b. Indicator will turn black if alternator for that respective engine is working properly.
c. Turn "OFF" emergency AC power and turn No. 1 (West) inverter "ON".	
22. Check propeller reversing operation.	22. A pre-flight reversing check need not be made on aircraft provided propeller reversing was used and operated satisfactorily on last landing.
→ CAUTION: Do not operate engine with propeller in reverse for extended periods of time. Operation with propeller in reverse position should be held to absolute minimum.	
a. Pull throttles back to idle (closed position).	

Run-Up (Cont.)	Special Instructions
22. (Cont.)	
b. Pull forward knobs (reverse knobs) on throttle controls up and back.	b. This will start propeller blades moving into reverse position and the red (reverse) indicator light will come on when they reach full reverse position.
c. Pull throttle reverse knobs on back to increase RPM in reverse, until they contact the detent.	c. The throttle rigging should be such that the engines are turning 1800 RPM when the detent is contacted.
d. After checking, push throttle reverse knob forward and down until it drops into notch, completing reverse cycle.	d. The red (reverse) indicator light should go out as soon as propeller blades reach low pitch.
e. Advance throttles to 1500 RPM.	
f. Depress respective feathering buttons momentarily to make sure propeller is out of reverse pitch.	f. (RPM should decrease). A rise in RPM will indicate propeller blades still in reverse.
g. Pull out each feathering button momentarily.	g. This is necessary in order to de-energize auto-feathering relays.
23. Check the No. 1 blade switch on the propeller and the governor solenoid valve operation.	23. With the propeller at full low pitch and the engine turning 1750 RPM pulling out on the feathering button to unfeather position will result in a RPM drop necessary to actuate the #1 blade switch and energize the solenoid valve. With continued holding out on the feathering button the RPM should stabilize and the propeller should not feather or reverse.

Check and Accomplish the Following Before Stopping Engines

1. Cowl flaps - "OPEN".
2. Propellers - "LOW PITCH".
3. Carguretor Air - "COLD".
4. Idle engine for two (2) minutes.
5. Cylinder head temperature - 170° Max.

5. This is necessary to scavenge oil out of engine.

   a. Do not shut cowl flaps for 15 minutes after engine shuts down.

Stopping Engines

1. Move right mixture control to "IDLE-CUT-OFF," to stop engine.

NOTE: Observe and record when primary compressor oil pressure low light comes on. (Disregard if compressor was disconnected)

Light located on upper portion of co-pilot's console should come on.

2. Turn "OFF" right ignition switch.

2. Do not turn "OFF" until propellers stop turning.

3. Check left hydraulic pump operation.

Check and Accomplish the Following Before Stopping Engines (Cont.)

Special Instructions

3. (Cont.)

   a. Relieve pressure on closed center system by operating wing flaps, until pressure drops to 1250 psi.

   b. Observe pressure gauge; pressure should build up rapidly to 1500 psi.

4. Move left mixture control to "IDLE CUT-OFF", to stop engine. → 4. If idle cutoff does not stop engine, leave mixture control in idle cut-off, close throttle turn ignition off, slowly open throttle.

5. Turn left ignition switch "OFF".

6. Check firewall shut-off valves for internal leakage.

   a. Close the right fire "SELECTOR ZONE 2". — a. Located under windshield glare shield.

   b. Turn on right boost pump.

   c. Observe fuel pressure gauge; if no pressure indication, valve is OK. — c. Be certain inverter is on.

   d. Open "SELECTOR ZONE 2" and turn off boost pump.

   e. Repeat a, b, c and d with the opposite engine.

7. Check fuel boost pump pressure.

   a. Turn boost pumps on "HIGH".

   b. Observe and record pressure indicated. — b. MCI limit 19-26.5 psi
   Service limit 17.5 26.5 psi

   c. Turn boost pump on "LOW".

   d. Observe and record pressure indicated. — d. Should not be less than 9.5 psi.

8. If required, pre-oil primary compressor as outlined in Chapter 17. — 8. Accomplish this step immediately after shut-down, while the engine is still warm.

9. Obtain an instrument mechanic to check cabin pressurization, if required. (Disregard if check was made during run-up) → 9. This check will be required after removal and installation of a new compressor.

Securing Cockpit

1. Apply surface control gust lock and neutralize controls. — 1. Control handle located to left of pilot's control wheel.

2. Turn "OFF" generator and inverter switches.

3. Turn both fuel selector valves to "TANK TO ENGINE & CROSSFEED".

4. Be certain brakes are parked.

5. Turn battery switch "OFF".

After Leaving Cockpit

1. Check engine for fuel, oil and hydraulic leaks.

2. Install pitot covers.

3. Obtain M-139 and record all malfunctioning items found on run-up.

Oil Dilution

A. When the outside air temperature is 40°F. (+ - 5°F.) or colder, or such temperature is anticipated the engine oil shall be diluted as follows:

   1. Determine manual "OIL DILUTION" valve in each nacelle is in "ON" position.

   2. Obtain and maintain an oil in temperature of 45 to 50°C.

   3. Operate engine at 1000 to 1200 RPM.

   4. Dilute as outlined below for various temperatures:

Anticipated Ground Temperatures	Dilution Period
40°F to 10°F (+ 5°C to -12°C)	2 minutes
10°F to -20°F (-12°C to -29°C)	4 minutes
-20°F and below (-29°C and below)	6 minutes

NOTE: The fuel boost pump also will operate when the oil dilution control switch is turned on.

   5. Minimum permissible oil pressure during dilution, 15 psi.

B. During the last minutes of dilution operation, dilute the propeller system as follows:

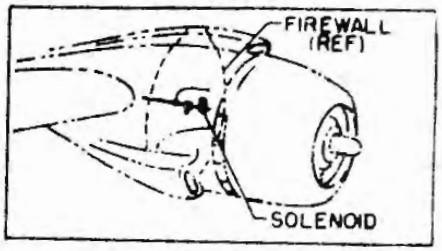
   1. Advance the throttle to obtain 1600 RPM and then move the propeller control to full "DECREASE RPM" position.

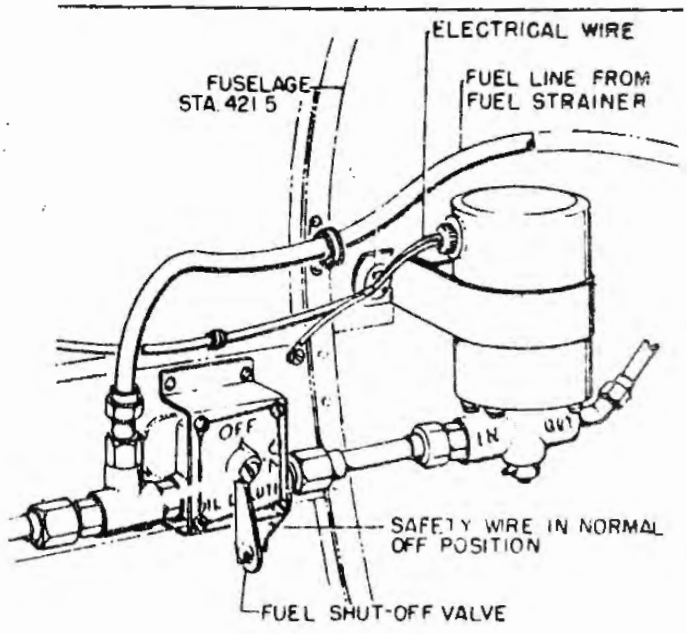
   2. When the RPM drops to 1200, return the propeller control to its original position and allow RPM to return to normal.

   3. Repeat this operation three times.

   4. Return the dilution switch to "OFF" and shut engine down.

   5. Safety the manual oil dilution valve in each nacelle in the "OFF" position, except when diluting.





ELECTRICAL SYSTEMS - GENERAL.

The electrical systems of the airplane are the 24 to 28 volt d-c power system, the 115 volt, 400 cycle, a-c power system, the 26 volt, 400 cycle a-c power system, the sectionalized bus system, and the power control switches.

D-C POWER SYSTEM - GENERAL.

Power is supplied from within the airplane by a battery, located in the belly of the fuselage between stations 389 and 411, or by the engine driven generators. Power can also be supplied from an outside source through the external power receptacle located on the right side of the fuselage between stations 389 and 411.

Positive current from d-c power sources is supplied to the electrical equipment by buses and cables, and returns to the negative d-c power source by grounding through the structure of the airplane.

D-C power system control switches and circuit breakers are located on the main circuit breaker panel, pilot's circuit breaker panel, hostess control panel, radio junction box panel, overhead switch panel, pilot's console panel, pilot's pedestal, co-pilot's console panel, anti-icing control panel, galley switch panel, belly circuit breaker panel and the inside and outside aft ramp control handles (see figure 1).

Fuses are located in the center distribution panel.

Operation Of D-C Power System (See figure 3).

The d-c power system is controlled by switches located under the "MASTER POWER CONTROL" and the "EMERGENCY LOAD REDUCTION" actuators on the overhead switch panel. Power is supplied to the units of the d-c power system through the generator circuit, battery circuit, external power circuit, and control switches.

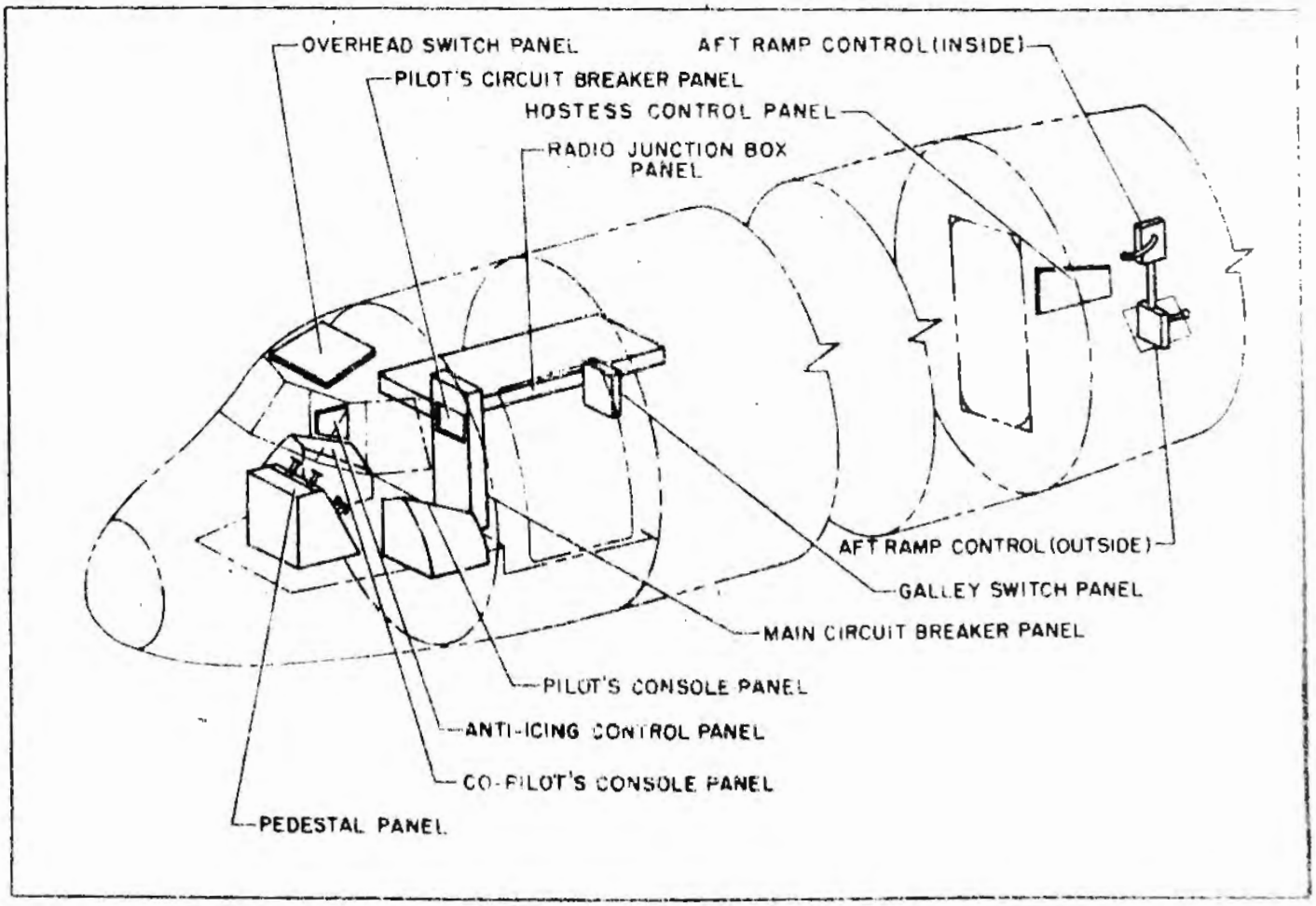


Figure 1. D-C And A-C Power System Control Panels

With the generator bus energized by the engine driven generators, battery or external power, the left and right distribution bus and the essential bus are energized. The remaining bus sections, may be energized by individual control switches and circuit breakers. Refer to Sectionalized Bus System.

D-C POWER SYSTEM GENERATOR CIRCUIT
(See figure 23).

The d-c power system generator circuit consists of the following pieces of equipment. Location of each piece is shown.

EQUIPMENT	LOCATION
Generators	Left and right engine accessory section.
Generator Isolation Relays	Left and right nacelle junction boxes.
Ground And Feeder Protection Relays	Left and right nacelle junction boxes.
Ammeter Shunts	Left and right nacelle junction boxes.
Generator Ballast Panel	Belly circuit breaker panel, in electrical access hatch.
Feeder And Back-Up Protection Relays	Left and right distribution support panels, in electrical access hatch.
Left And Right D-C Regulator Panel Fuses	Center distribution panel on generator bus, in electrical access hatch.
Regulator And Control Panels	Right side, in electrical access hatch.
Field Reset Control Relays	Belly electrical junction box in heater access hatch.
Monitored Bus Control Relays	Belly electrical junction box in heater access hatch.
"GENERATOR CONTROL" Circuit Breakers	Belly circuit breaker panel in electrical access hatch.
Generator Control Switches	Overhead switch panel.
Generator Overheat Lights	Overhead switch panel.
Generator Field Trip Lights	Overhead switch panel.
Ammeters	Pilot's console panel.
D-C Voltmeter	Pilot's console panel.
Voltmeter Selector Switch	Pilot's console panel.
"GEN.-BAT. RESET AND OVERHEAT LIGHTS" Circuit Breaker	Pilot's circuit breaker panel.
"ZONE 2" Shut Off Switches	Bulkhead, forward of instrument panel

Operation Of The Generator Circuit
(See figure 2).

The main source of power on the airplane are the two engine-driven generators. After engine has been started, remove the external power supply, turn the battery switch and the corresponding generator control switch, located on the overhead switch panel, to the "ON" position. The circuit will be completed through the shut-off switch, actuated by the corresponding "SELECTOR ZONE 2 FIREWALL SHUT-OFF" control located on the glare shield, closing the feeder and back-up protection contactor and connecting the generator to the bus. Check generator "FIELD TRIP" indicator light, located on overhead switch panel. If light is burning, place the generator control switch to "RESET" position and light should go out. Return the switch to the "ON" position.

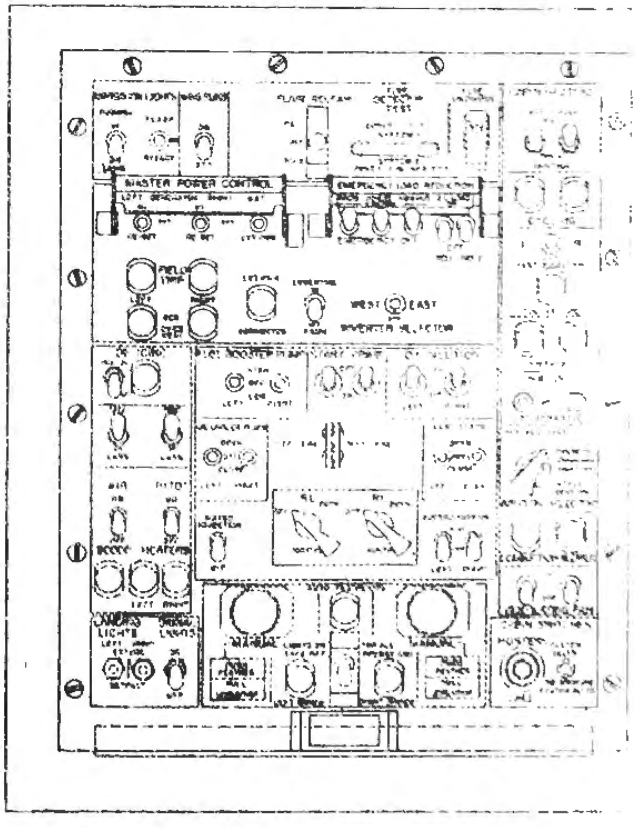


Figure 2. D-C And A-C Power System Control Switches

Generators.

There are two engine driven generators, each rated 300 - 350 amperes at 30 volts, over a speed range of 3450 to 8500 rpm, through the step-up gears to the ratio of 3 to 1. When the engines are operating at 1350 rpm or over, the generators are capable of supplying their full rated load. The generators are ram air cooled through a duct surrounding the oil cooler intake, therefore the continuance rated full load should only be used in flight. On the ground continuance rated full load should only be used for a very short time.

NOTE

When the necessity for a generator change arises, due to overhaul etc. it is recommended only the Eclipse-Pioneer Model 30E02-11B or the 30E02-11C generators be used as replacements. The 30E02-11C is the preferable generator if available. Under no condition are the Eclipse-Pioneer Generator Models 30E02-11 or 30E02-11A to be used as a replacement.

Generator Isolation Relay.

The generator isolation relays are single pole single throw type, rated at 400 amperes. The coil of the generator isolation relay is controlled by the field relay in the regulator and control panel. When a fault causes the field relay to be tripped the generator isolation relay will open and disconnect the generator feeders from the generator ground and feeder protection relay.

Generator Ground And Feeder Protection Relay. (See Figure 3).

If a ground-fault occurs within the generator or its feeders between the two coils on the generator ground and feeder protection relay the current through the two coils will be unequal. At a current differential of approximately 100 amperes, the ground and feeder protection relay contacts will close and trip the field relay. The generator will then b isolated from the system.

Feeder And Back-Up Protection Contactor. (See Figure 4).

If generator voltage drops below generator bus voltage, reverse current will flow from the generator bus through the feeder and back-up protection contactor, and through the generator. At approximately 30 amperes reverse current, one of the coils of the polarized differential relay will open the relay contacts. This will open one of the dual contacts in the feeder and protection contactor, taking the generator off the generator bus. If this contact should fail to open when reverse current flows, the reverse current would increase rapidly. At approximately 100 amperes reverse current, the current coil on the back-up protection relay will force its contacts open and the other dual contacts will open taking the generator off the generator bus. If a heavy surge of reverse current flows from the generator bus through the generator, the dual contacts will open almost simultaneously.

Feeder Protection.

The parallel feeders between the feeder and back-up protection contactor and the generator ground and feeder protection relay are protected by the above units. Normally, the current flow through the outer coils of either one of the feeder protection relays is of "bucking" polarity, and the feeder relays in both units will remain open. If a ground fault occurs along either of the two parallel feeders, the direction of current flow in the outer coils of the relays will be such that a large net amount of flux will be produced. At approximately 100 amperes current differential, the feeder relay contacts will close, tripping the field relay. This will isolate the generator from the generator bus.

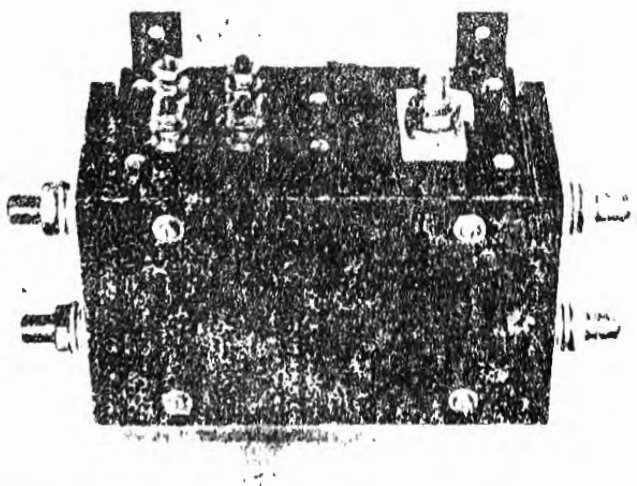


Figure 3. Generator Ground and Feeder Protection Relay.

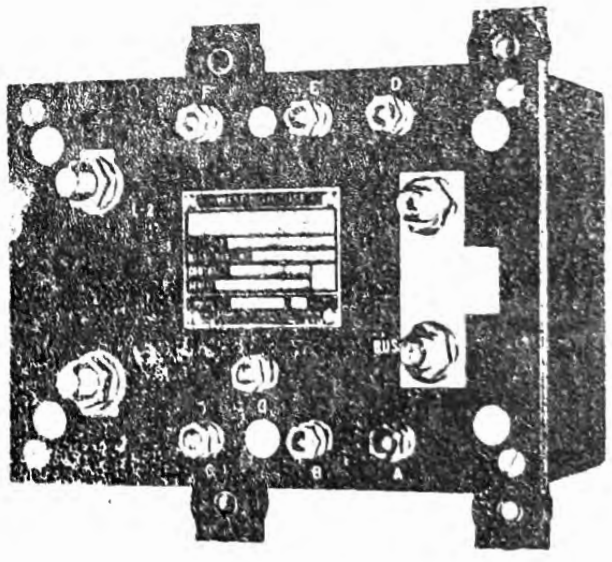


Figure 4. Feeder and Back-Up Protection Contactor.

Field Reset Control Relays.

The field reset control relays are double pole, double throw type and are used to control current flow, to the reset coil of the field relays in the regulator and control panels. Once the field relays are locked in place, the field reset control relays will close, removing the circuit from the reset coil.

Monitored Bus Control Relays.

The monitored bus control relays are double pole, double throw type. Both generator circuits have one of these relays incorporated in the system. When the generator voltage is higher than the battery voltage at the generator bus, the polarized differential relay contacts will close and energize the monitored bus control relay. One contact will complete the ground circuit of the monitored bus relay. The monitored bus can only be energized by generator power, an external power source or the "MON. BUS OVRIDE" switch.

"ZONE 2" Shut Off Switch.

The normally closed micro switch is actuated by the "SELECTOR ZONE 2 FIREWALL SHUT-OFF" handle located on the glare shield, and opens the feed circuit for the coil of the contactor in the feeder and back-up protector contactor assembly, also disconnects the feed for the generator isolation relay. The generator would then be disconnected at the generator isolation relay, and the generator bus disconnected by the back-up protection contactor.

GENERATOR OVERHEAT LIGHTS.

The generator overheat lights are energized through a "OVERHEAT LIGHTS" circuit breaker on the pilots circuit breaker panel. A plugstat thermal switch inside the generator, with one connection internally grounded, will close the circuit when an overheat condition exists within the generator and light the generator overheat light to warn the flight crew of the overheat condition.

The overheat condition can usually be eliminated by reducing the load on the generator and increasing engine RPM, on the ground, to furnish more cooling air to the generator.

If the light goes out under either of the two methods, the system can be considered satisfactory for continuation of a flight to termination. The system should then be thouroughly checked and remedial action taken. The plug stat should be replaced whenever it has caused an overheat warning for any reason.

Generator Field Trip Lights.

The field trip lights will indicate the latch-type field relay, in the regulator and control panel, has been tripped due to a fault or a condition not normal. Current is supplied to the light through a 10 ampere fuse, and through the field relay trip contacts.

Generator Control Switches.

The generator control switches are triple pole, triple throw type, having an "OFF" and "ON" stationary position and a momentary "RESET" position. The "RESET" position allows current to flow through the "GEN RESET" circuit breaker, to energize the field relay reset coil and also energize the field reset control relay after the field relay has been locked in place. The "ON" position closes the circuit permitting the feeder and back-up protection contactor and the generator isolation relay to operate, when generator voltage is higher than the generator bus voltage.

Generator Ammeter Shunt And Ammeter.

The generator ammeter shunt, rated at 500 amperes, is in the generator ground circuit. The amount of current the generator is supplying is measured across the shunt. The ammeters will indicate the amount of current each generator is supplying.

D-C Voltmeter And Selector Switch.

The d-c voltmeter and selector switch are in series, the negative side of the voltmeter having a ground circuit. The rotary, single pole, selector switch may be placed to six different selections, "OFF", "BATTERY", "ESS. BUS", "FWD. DIST. BUS", "L.H.GEN." and "R.H. GEN.". The voltage of each source will be indicated by the d-c voltmeter.

Generator Ballast Panel.

The generator ballast panel has been added to reduce the voltage of the equalizer circuit to normal operating voltage. The wiring of the generator circuit is of large gauge, used for generators rated at 400 amperes. The 400 ampere generators may be installed at a later date, at which time the generator ballast panel will be removed.

"GEN. CONTROL" Circuit Breakers.

The left and right generator control circuit breakers are located on the belly circuit breaker panel. Should the circuit from the field relay contacts to the feeder and back-up protection contactor as well as the voltmeter selector switch circuit, become faulted to ground, the breaker would trip. This would disconnect the generator from the generator bus.

"GEN. - BAT. RESET AND OVERHEAT LIGHTS" Circuit Breaker.

Current is supplied from the essential bus through the "GEN. - BAT. RESET AND OVERHEAT LIGHTS" circuit breaker, to the "RESET" position of the left and right generator control switches, and to the "RESET" position of the battery-essential bus reset switch. Current is also supplied from the circuit breaker for the left and right "GEN. OVERHEAT" lights. Should a fault occur the circuit breaker will trip and open the circuits.

REGULATOR AND CONTROL PANEL (See figure 5).

Each regulator and control panel contains the following equipment; carbon-pile regulator, field relay, equalizer disconnect relay, rectifier, polarized differential relay, overvoltage relay, and ballast lamps. All relays and circuit components, except the voltage-adjusting rheostat are grouped together, in order that they may be protected by a dust-proof cover. Voltmeter jacks are provided on the front of the unit to provide easy connections to a precision voltmeter while voltage adjustments are being made. The panel can be removed from the shock-mounted base assembly, by loosening the wing bolt at the front of the panel and pulling the unit straight out, this will disconnect the electrical plug.

Carbon Pile Regulator (See figure 5).

The carbon-pile regulator, rated at 90 watts, holds the generator voltage at a predetermined value by automatically varying the resistance in series with the generator shunt field.

Ballast Lamps.

Two ballast lamps are used in the equalizer circuit to prevent system voltage being lowered excessively by a generator which is operating, but is not connected to the generator bus. When the two generators are connected to the generator bus, equalizer action tends to force equal divisions of the load to both generators.

Manual Reset (See figure 5).

The manual reset button on the front of the regulator and control panel will reset the field relay, if the relay has been tripped and the generator bus de-energized. The button should not be depressed for more than one second. If the button immediately trips, a faulty system is indicated.

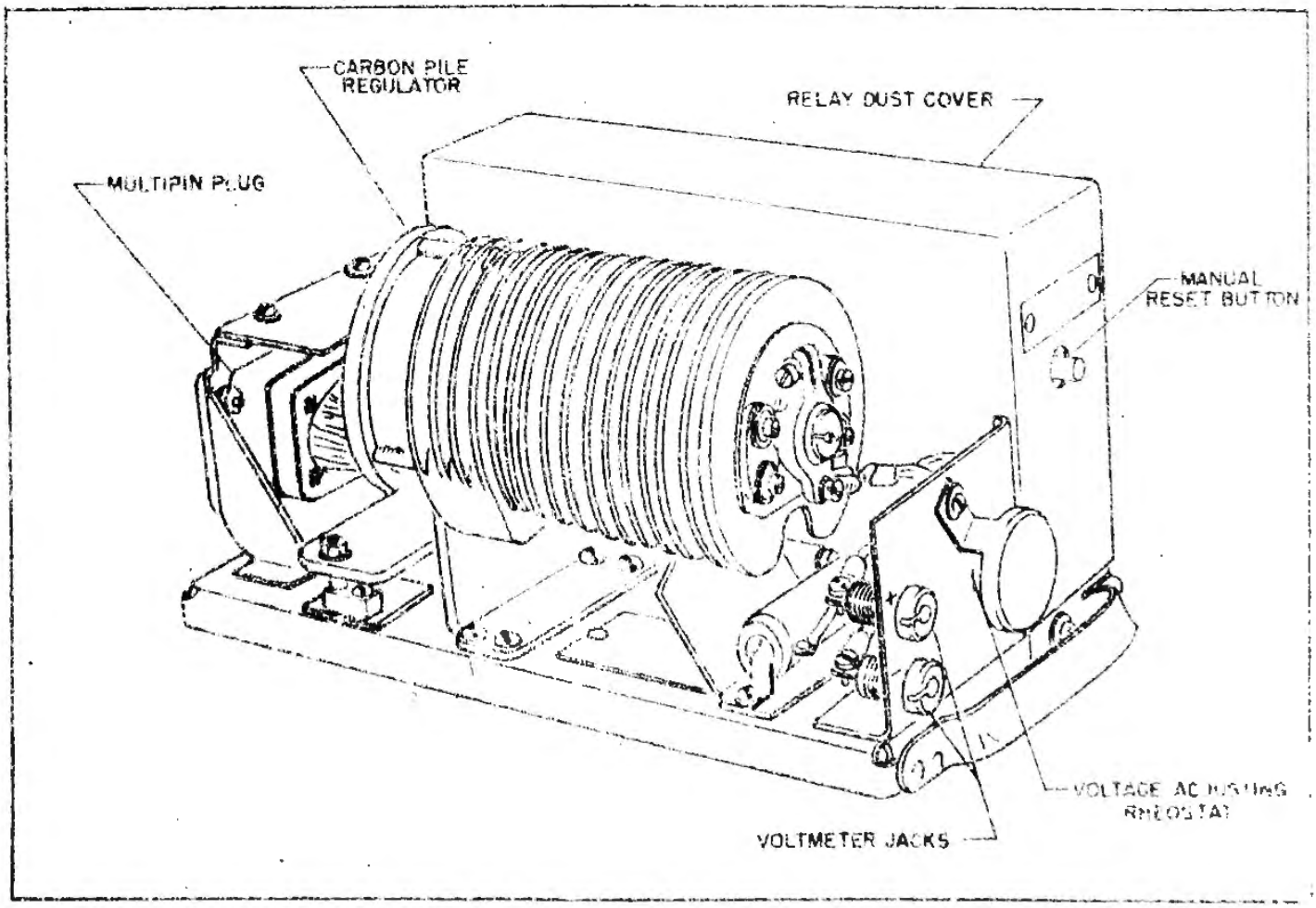


Figure 5. D-C Power System Regulator And Control Panel

Field Relay (See figure 7).

The latch-type field relay disconnects the generator field, and isolates the generator from the system, when an electrical fault occurs in the system. Protection relays, located in the system, energize the field relay trip coil when a fault occurs.

Rectifier.

The selenium rectifier is connected in four parallel banks, each having two cells connected in series. No current flows through the rectifier as long as the generator operates with correct polarity. If polarity of the generated voltage reverses, the rectifier will permit current to flow through the trip coil of the field relay. This will disconnect the generator field and isolate the generator from the system.

Equalizer Disconnect Relay (See figure 6).

When the generator control switch is placed in the "OFF" position the coil of the equalizer disconnect relay is de-energized. When the contacts of this relay open, the equalizer circuit to the generator is opened, and also de-energizes one of the coils on the polarized differential relay.

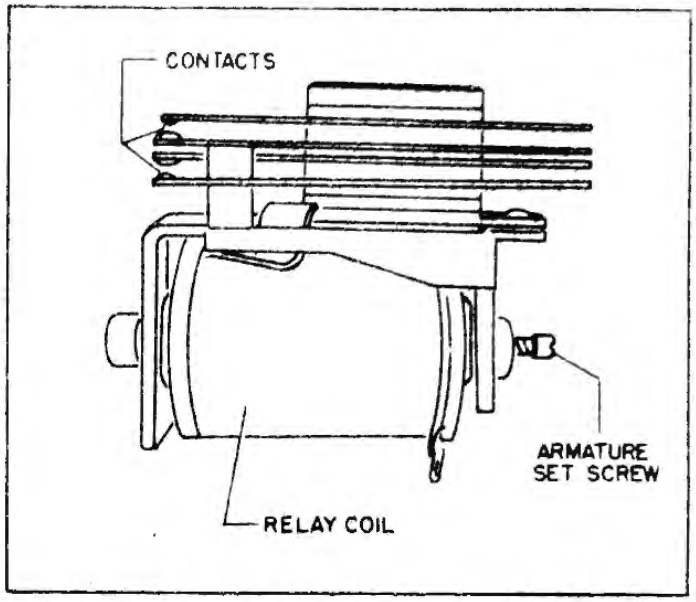


Figure 6. D-C Power System Equalizer Disconnect Relay

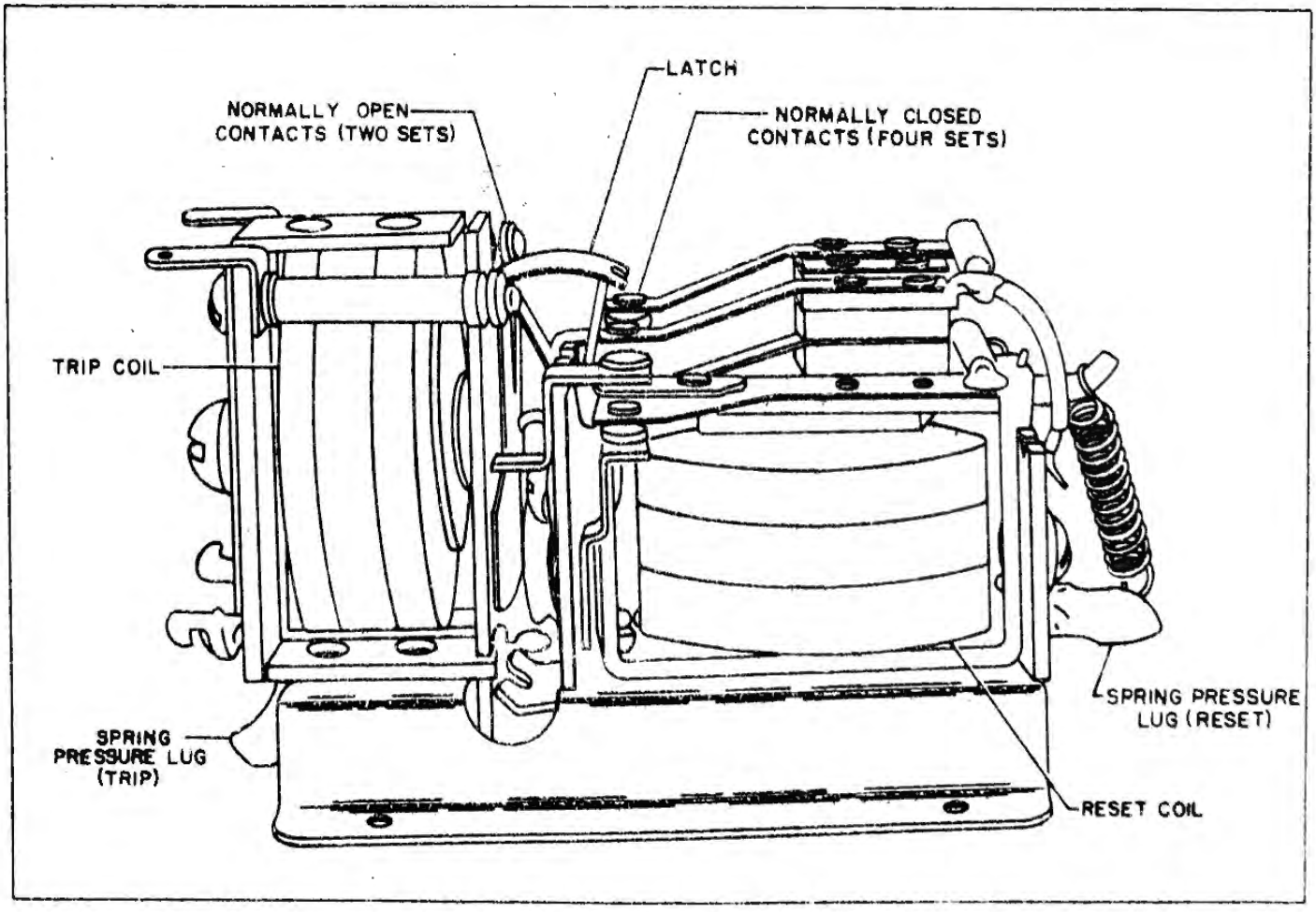


Figure 7. "Latch-Type" Field Relay

Polarized Differential Relay (See figure 8).

The polarized differential relay controls the ... of 32 circuit, to one of the coils in the feeder and bus ... protection contactor, and ... a protection relay to the system when more than one generator is used. It permits closing of the contactor when the generated voltage is big enough to supply current to the generator bus, but causes the contactor to be opened when the generator bus voltage is higher than the generator voltage.

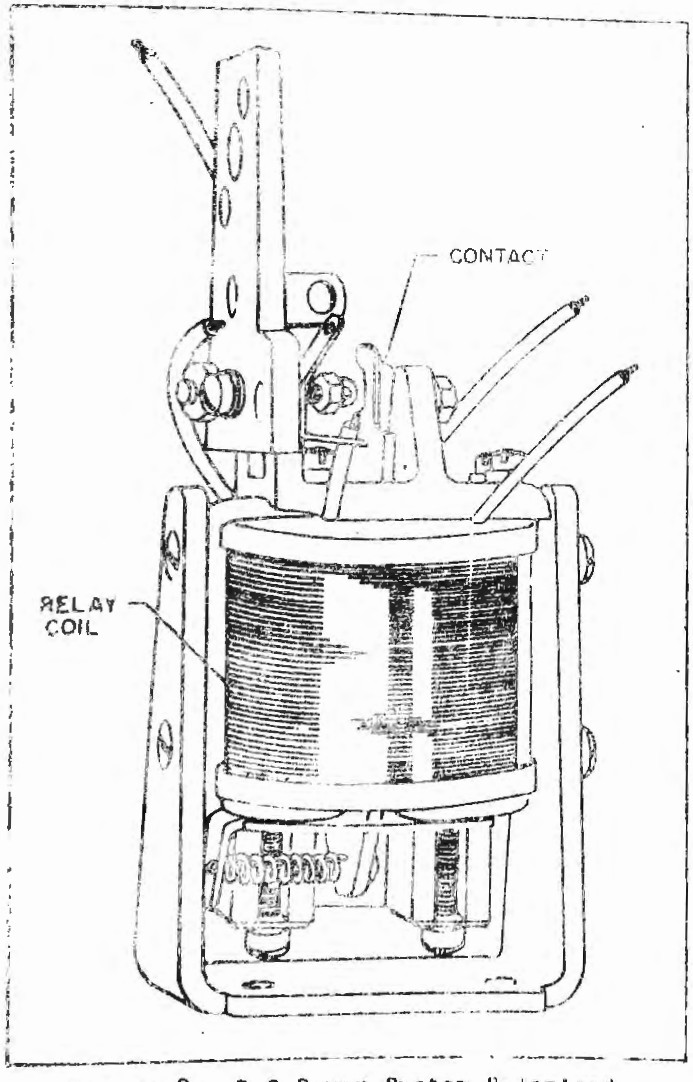


Figure 8. D-C Power System Polarized Differential Relay

Overvoltage Relay (See figure 9).

When a fault occurs which permits a gene... to produce higher than normal voltage, ... overvoltage relay closes and trips the ... relay, isolating the generator from the sys...

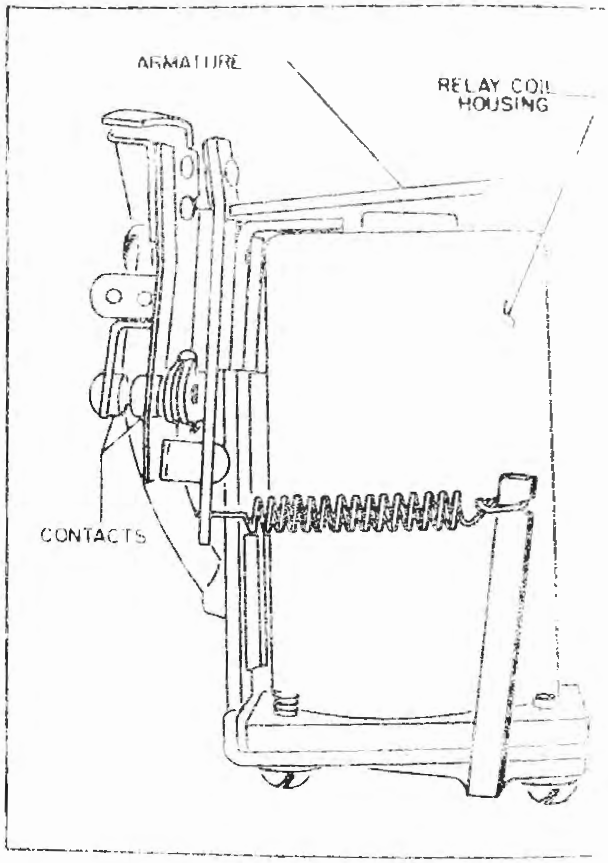


Figure 9. D-C Power System Overvoltage Relay

D-C POWER SYSTEM BATTERY CIRCUIT.
(See Figure 10).

The d-c power system battery circuit consists of the following pieces of equipment. Location of each piece is shown.

EQUIPMENT	LOCATION
Battery	Left side, in electrical access hatch #84.
Ammeter Shunt	Left side, in electrical access hatch #84 at station 428.
Battery Relay	Left hand distribution panel in electrical access hatch #84.
Reverse Current Circuit Breaker	Center distribution panel, aft, in electrical access hatch #84.
"BATTERY RELAY CONTROL" Circuit Breaker	Belly circuit breaker panel, in electrical access hatch #64.
"BATTERY RESET CONTROL" Circuit Breaker	Belly circuit breaker panel, in electrical access hatch #84.
"GEN-BAT. RESET AND OVERHEAT LIGHTS" Circuit Breaker	Pilot's circuit breaker panel.
"BAT.-EXT. PWR." Control Switch	Overhead switch panel.
"BAT. C.B. RESET" Switch	Pilot's console panel.
Ammeter	Pilot's console panel.
Voltmeter And Selector Switch	Pilot's console panel.
Reverse Current Circuit Breaker Trip Indicator Light	Pilot's console panel.

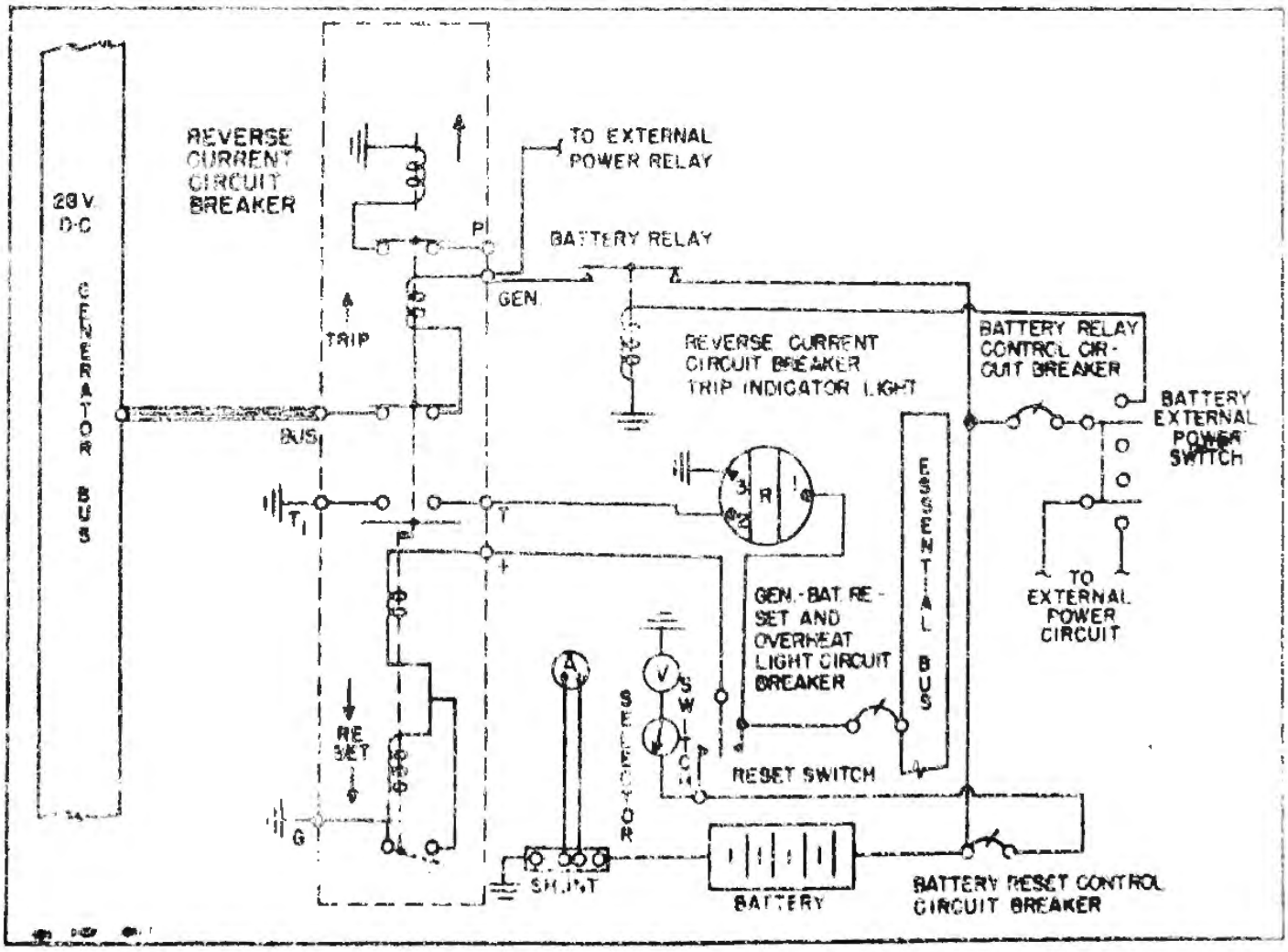


Figure 10. Battery Power Circuit Schematic

Operation Of The Battery Circuit (See figure 10).

Battery power is supplied to the generator bus by placing the "BAT.-EXT. PWR." switch on the overhead switch panel, to the "BAT." position. This operates the battery relay and connects battery power to the generator bus through the latch type hold closed reverse current circuit breaker. Should battery power fail to supply the generator bus, press the "BAT. C.B. RESET" switch on the pilot's console panel, to the "BAT." position. This will reset the reverse current circuit breaker. When the battery alone is supplying the generator bus, the monitored bus cannot be energized. A generator or an external power source will be needed to energize the monitored bus. Refer to SECTIONALIZED BUS SYSTEM of this chapter.

Battery (See figure 26).

The battery is located in the Electrical Access hatch #84. It is a 24 volt battery with a 42 ampere hour rating and is installed in a moulded rubber container assembly. The battery is readily accessible for servicing without being removed from the airplane. The battery box is on a cradle support that can be swung down to a lowered position where the battery can be either serviced or removed. The cover of the box remains in the airplane. When the battery is swung up into place and the cover locked in place, the electrical connections are made as well as the vent tubing properly connected to the battery. There is a battery pad under the battery that has been soaked in bicarbonate of soda and dried. Any electrolyte escaping from the battery is absorbed by the pad. Any battery vapors leave the airplane by way of the vent tube.

CAUTION

When removing or replacing the battery, slip two pieces of five eighths inch rubber hose about four inches long over the battery terminals at all times, to prevent the possibility of arcing against the airplane skin or structure.

Battery Ammeter Shunt And Ammeter (See figure 21).

The 50 millivolt external shunt, located in the Electrical Access Hatch #84 at station 428 left hand side, is installed in the negative side of the battery circuit. Attached to the battery shunt by an electrical circuit is the battery ammeter which is located on the pilot's console panel. The battery ammeter has a calibrated range from - 150 amperes to + 150 amperes with a center zero position.

Battery Relay (See figure 31).

The battery relay is located on the left hand distribution panel in the Electrical Access Hatch #84. The battery relay is used in the battery circuit to close or open the power circuit between the battery and the generator bus. The coil circuit of the battery relay is controlled by the "BAT-EXT.PWR." control switch located on the overhead switch panel.

Reverse Current Circuit Breaker (See figure 11).

The reverse current electrical reset circuit breaker is mounted on the center distribution panel and located in the Electrical Access Hatch #84. This circuit breaker through which the battery power circuit is connected to the generator bus and vice versa, will protect the generator bus in case the battery or its wiring becomes faulted to ground.

However, the capacity of this breaker in the reverse direction will permit the charging current required by the battery to be carried. Under very abnormal conditions, such as a momentary overvoltage feeding a discharged battery, the high charging current may trip the reverse current circuit breaker, which will be indicated by the red warning light on the pilot's console panel. A "BAT. C.B. RESET" switch, adjacent to the light, is provided so the reverse current circuit breaker can be electrically reset if a generator is supplying the essential bus or if the battery is connected. The manual "PRESS TO RESET" plunger is located on the reverse current circuit breaker housing.

Figure 11. D-C Power System Reverse Current Circuit Breaker.

"BAT. C.B. RESET" Switch (See figure 21).

The "BAT. C.B. RESET" switch on the pilot's console panel is a single-pole double-throw type switch. Both positions being momentary. Pressing the switch to the "BAT." position will close the circuit from the battery to the reset coil of the reverse current circuit breaker. The battery is protected by the "BATTERY RESET CONTROL" circuit breaker. Pressing the switch to the "ESS. BUS" position will close the circuit from the essential bus to the reset coil of the reverse current circuit breaker. The reverse current circuit breaker cannot be reset from the "ESS. BUS" position with external power. A generator must be operating to energize the generator bus and in turn the essential bus. The external power circuit to the generator bus is broken by the reverse current circuit breaker when it is tripped.

"BAT. - EXT. PWR." Switch (See figure 2).

The "BAT-EXT. PWR." switch is located on the overhead switch panel, and is of the double-pole double-throw type having a "BAT.", "OFF" and an "EXT. PWR." position. Placing the switch to the "BAT." position will close the circuit from the battery to the coil of the battery relay.

Airplanes 401 through 412 must observe the following CAUTION until modification of the external power circuit has been incorporated.

CAUTION

With external power connected and the "BAT. - EXT. PWR." switch in the "BAT." position, the airplane battery will be connected to all electrical loads, including the monitored bus if the "MON. BUS" switch is in the "ON" position.

Voltmeter And Selector Switch (See figure 21).

The "D.C. VOLTMETER" and the "VOLTMETER SELECTOR" switch located on the pilot's console panel, are wired in series with the negative side of the voltmeter having a ground circuit. The rotary single-pole "VOLTMETER SELECTOR" switch may be placed to six different selections which are as follows: "OFF", "BATTERY", "ESS. BUS", "FWD. DIST. BUS", "L.H. GEN." and the "R.H. GEN". The voltage of each source will be indicated by the "D.C. VOLTMETER".

"BATTERY RELAY CONTROL" Circuit Breaker.

The "BATTERY RELAY CONTROL" toggle type circuit breaker is installed on the belly circuit breaker panel which is located in the Electrical Access Hatch #84. Power is supplied through the "BATTERY RELAY CONTROL" circuit breaker from the battery to the "BAT.-EXT.PWR." switch, located on the overhead switch panel.

"BATTERY RESET CONTROL" Circuit Breaker.

The "BATTERY RESET CONTROL" toggle type circuit breaker is installed on the belly circuit breaker panel which is located in the Electrical Access Hatch #84. Power is supplied from the battery through the "BATTERY RESET CONTROL" circuit breaker to the "BAT.C.B.RESET" switch and the "VOLTMETER SELECTOR" switch, located on the pilot's console panel.

"GEN. - BAT. RESET AND OVERHEAT LIGHTS" Circuit Breaker.

The "GEN.-BAT. RESET AND OVERHEAT LIGHTS" circuit breaker, located on the pilot's circuit breaker panel, is a toggle type breaker. Power is supplied from the essential bus through the "GEN.-BAT. RESET AND OVERHEAT LIGHTS" circuit breaker to the "BAT. C.B. RESET" switch and the two generator "OVERHEAT" lights.

Reverse Current Circuit Breaker Trip Indicator Light (See figure 21).

The reverse current circuit breaker trip indicator light on the pilot's console panel, is of the push-to-test type having a red jewel shade covering the single contact bayonet type lamp. The light is used to give indication that the reverse current circuit breaker has tripped, only when the generator or generators are supplying the generator bus. The light will not indicate the reverse current circuit breaker tripped condition when the generator or generators are not supplying the generator bus and the battery or an external power source fails to supply the generator bus.

Power is supplied to the light from the 28 volt d-c essential bus through the "GEN. - BAT. RESET AND OVERHEAT LIGHTS" circuit breaker on the pilot's circuit breaker panel. The ground circuit is supplied through the tripped contacts of the reverse current circuit breaker. The ground for the push-to-test circuit of the light is supplied from a ground terminal within the pilot's console panel.

D-C POWER SYSTEM EXTERNAL POWER CIRCUIT

(See Figure 12.)

The d-c power system external power circuit consists of the following pieces of equipment. The location of each piece is shown.

EQUIPMENT	LOCATION
External Power Receptacle	Right hand outboard of the electrical access hatch #84.
External Power Relay Circuit Breaker	External power receptacle box.
External Power Relay	Right hand distribution panel.
Reverse Current Circuit Breaker	Center distribution panel, aft, in electrical access hatch #84.
External Power Control Relay	Belly electrical junction box in heater access hatch #83.
Rectifier	Belly electrical junction box in heater access hatch #83.
External Power Light	Overhead switch panel
"BAT-EXT. PWR". Switch	Overhead switch panel
Reverse Current Circuit Breaker Trip Indicator Light	Pilot's console panel
"BAT. C.B. RESET" Switch	Pilot's console panel

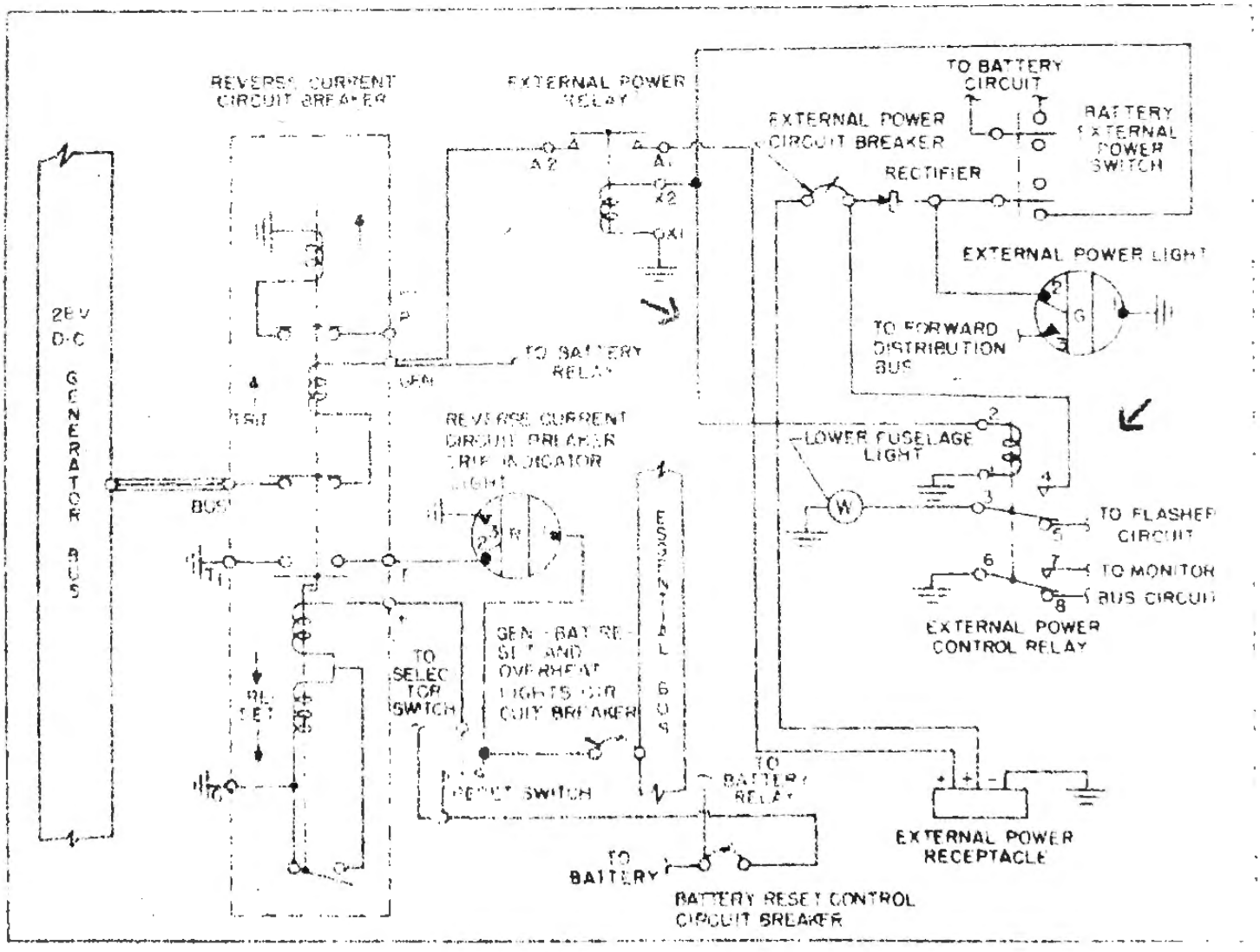


Figure 12. External Power Circuit Schematic

Operation Of The External Power Circuit. (See Figure 12)

When an external power source is connected to the external power receptacle located on the right side, outboard of the electrical access hatch #84 and the "EXT. PWR. RELAY" circuit breaker, also located in the receptacle box, is in the normally "ON" position, a circuit is completed to the "BAT.-EXT. PWR." switch and "EXT. PWR. CONNECTED" indicator light installed on the overhead switch panel. A rectifier installed in the circuit between the "EXT. PWR. RELAY" circuit breaker and the "BAT.-EXT. PWR." switch protects against damage by reverse polarity at the external power receptacle. With polarity reversed, the "EXT. PWR. CONNECTED" indicator light will not be illuminated.

Place the "BAT.-EXT. PWR." switch in the "EXT. PWR." position, this will complete the control circuit to the coils of the external power relay and the external power control relay causing these relays to be energized.

When the external power control relay is energized, on set of contacts closes a circuit from the external power source to the lower fuselage light causing the lamp to be illuminated. A second set of contacts of the external power control relay will close thus completing a ground circuit for the coil of the monitored bus relay, which is in turn controlled by the "MON. BUS" switch and the "MON. BUS O'RIDE" switch on the overhead switch panel. Refer to SECTIONALIZED BUS SYSTEM of this chapter for information concerning the Monitored Bus.

When the external power relay is energized, the power circuit is completed from the external power source through the latch-type held closed contacts of the reverse current circuit breaker to the generator bus. Should the external power source fail to supply the generator bus, the reverse current circuit breaker may be tripped. This breaker may be reset either manually or electrically, refer to D-C POWER SYSTEM BATTERY CIRCUIT of this chapter for information concerning the D-C Reverse Current Circuit Breaker.

"EXR. PWR. RELAY" Circuit Breaker. (See figure 12A).

The "EXT. PWR. RELAY" toggle type circuit breaker is installed in the external power receptacle box. This circuit breaker is normally left in the "ON" position and protects the circuit to the coil of the external power control relay, external power relay and to the "EXT. PWR. CONNECTED" indicator light and lower fuselage light.

External Power Control Relay.

The external power control relay is of the double-pole, double-throw, single break type relay and is installed in the belly electrical junction box. The normally closed contacts of this relay completes a ground circuit for the cabin heater cut-off relay and also completes a feed circuit to the lower fuselage navigation light, when the navigation lights circuit is energized. The external power control relay is controlled by the "BAT.-EXT. PWR." switch when an external power source is connected to the external power receptacle. The closed contacts of this relay when energized completes a ground circuit for the monitored bus control relay and completes a feed circuit from the external power source to illuminate the lower fuselage navigation light.

External Power Rectifier.

The external power rectifier is of the 28 volt d-c metallic type and is installed in the belly electrical junction box. The rectifier is used in the external power control circuit to prevent an external power source of reverse polarity, to supply power to the electrical system. Current will flow through the rectifier in one direction only.

External Power Receptacle (See figure 12A).

The external power receptacle is of the three prong type, installed in the external power receptacle box, located on the right side of the belly of the fuselage, outboard of the electrical access hatch #84. The receptacle is used for connecting an external 28 volt d-c power source to the d-c power distribution system for ground operation of the airplane's electrical equipment.

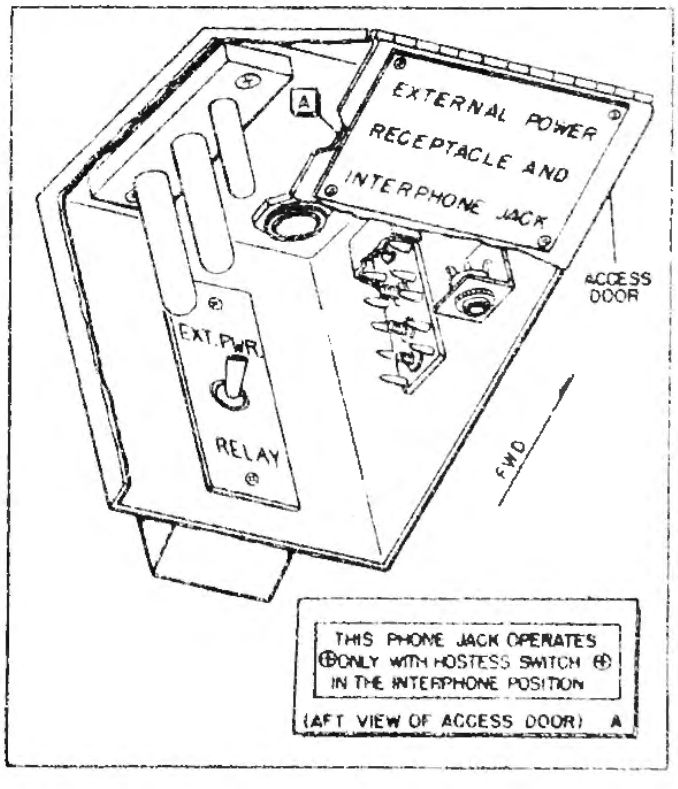

EXTERNAL POWER RECEPTACLE AND INTERPHONE JACK
ACCESS DOOR
EXT. PWR. RELAY
FWD
THIS PHONE JACK OPERATES ONLY WITH HOSTESS SWITCH IN THE INTERPHONE POSITION
(AFT VIEW OF ACCESS DOOR) A

Figure 12A. External Power Receptacle Box

"EXT. PWR. CONNECTED" Indicator Light. (See Figure 2).

The "EXT. PWR. CONNECTED" indicator light, located on the overhead switch panel, is of the push-to-test type having a green jewel shade installed over the internal lamp. The indicator light will be illuminated whenever an external power source is connected to the external power source is connected to the external power receptacle. The normal circuit of the indicator light is supplied from the external power source through the "EXT. PWR. RELAY" circuit breaker. The push-to-test circuit of the indicator light is supplied from the 28 volt d-c forward distribution bus through the "MISC. WARN. LTS. & VOLTMETER" circuit breaker, located on the main circuit breaker panel.

"BAT.-EXT. PWR." Switch (See figure 2).

The "BAT.-EXT. PWR." switch is located on the overhead switch panel and is of the double-pole, double throw type, having a "BAT.", "OFF" and an "EXT. PWR." position. Placing the switch to the "EXT. PWR." position will close the circuit from the external power source to the coils of the external power relay and the external power control relay.

Airplanes 401 through 412 must observe the following CAUTION until modification of the external power circuit has been incorporated.

CAUTION

With an external power source connected and the "BAT.-EXT. PWR." switch in the "BAT." position, the airplane's battery circuit will be connected to all electrical loads, including the monitored bus if the "MON. BUS" switch is in the "NORMAL" position.

External Power Relay.

The external power relay located on the right hand distribution panel in the belly electrical access hatch #84, is of the single-throw, double-break type relay. This relay is controlled by the "BAT.-EXT. POWER" switch when an external power source is connected to the external power receptacle. The purpose of this relay is to close or open the external power circuit from the 28 volt d-c external power source to the generator bus.

SECTIONALIZED BUS SYSTEM (See figure 13).

The d-c power distribution system consists of a sectionalized bus system, incorporating the following sections.

The sectionalized bus system incorporated in this airplane assures reliability of the power system, by physically and electrically protecting the generator bus. By distributing power from this bus by means of protected feeders to many busses, the continuation of operation of most of the equipment is assured in the event one bus or feeder becomes faulted to ground.

BUS SECTIONS	LOCATIONS
Generator Bus	Center distribution panel, aft, in electrical access hatch.
Left Hand Distribution	Left hand distribution panel, aft, in electrical access hatch.
Right Hand Distribution Bus	Right hand distribution panel, aft, in electrical access hatch.
Forward Distribution Bus	Main circuit breaker panel.
Monitored Bus	Main circuit breaker panel.
Emergency Bus	Pilot's circuit breaker panel.
Essential Bus	Pilot's circuit breaker panel.
Interphone Bus	Radio junction box.
Essential Radio Bus	Radio junction box.
Radio Bus	Radio junction box.
Hostess Bus	Hostess control panel.
Galley Bus	Galley switch panel.
Left Nacelle Bus	Left nacelle junction box.
Right Nacelle Bus	Right nacelle junction box.

Generator Bus.

The generator bus is the main power source of the sectionalized bus system. The panel used to mount the generator bus, in the electrical access hatch, is of an insulating material and the assembly is installed in an inverted position to shut out the possibility of ground faults from foreign objects, even when the insulating cover for the generator bus is not in place. The generator bus feeds several bus sections, and is protected by fuses and back-up protection contactors. The bus can be energized by the engine driven generators, battery, or an external power source. Refer to Chapter 26 for wiring diagrams.

Left Hand Distribution Bus.

The left hand distribution bus is installed in the left hand distribution panel, in the electrical access hatch. The bus is energized directly from the generator bus through a 30 ampere fuse and is used as a protected source from which current can be supplied to the following circuits; hostess bus remote circuit breaker, left hand exterior lights, airscoop blanket, left hand fuel booster pump, and the left hand recirculating air blower.

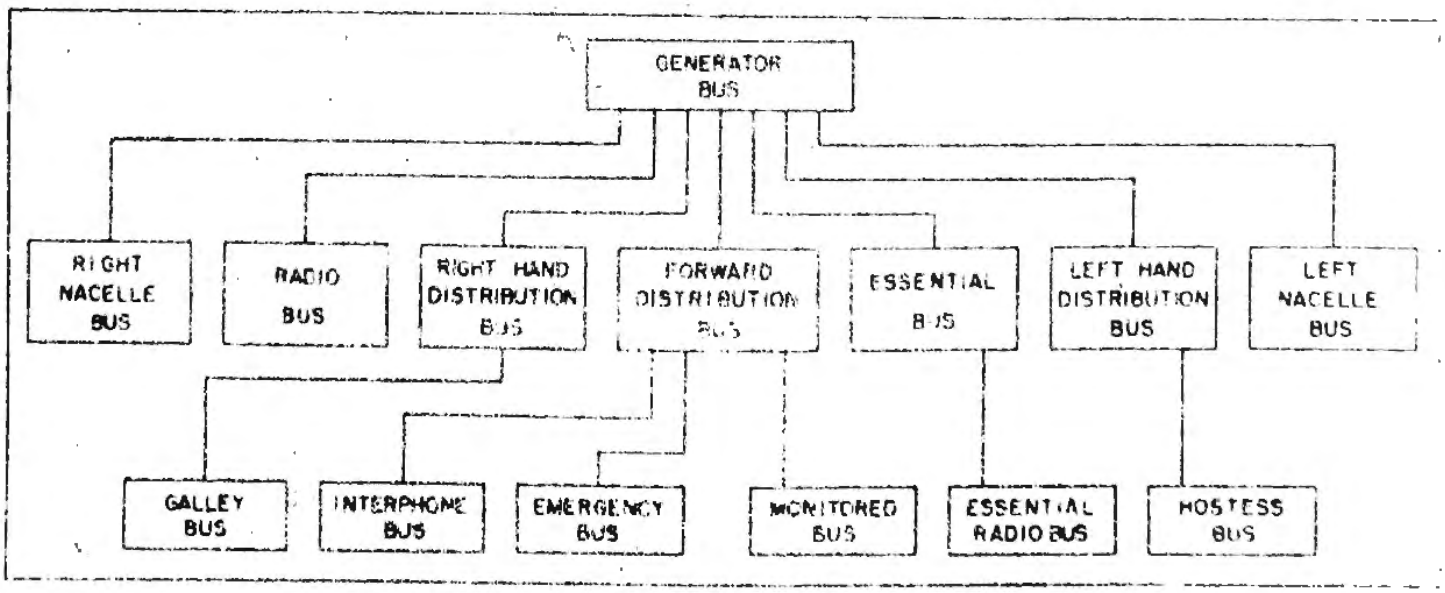


Figure 13. D-C Power Sectionalized Bus System

Right Hand Distribution Bus.

The right hand distribution bus is installed in the right hand distribution panel, in the electrical access patch. The bus is energized directly from the generator bus through a 300 ampere fuse, and is used as a protected source from which current can be supplied to the following circuits: right hand exterior lights, emergency hydraulic pump, galley power, right hand fuel booster pump, and the right hand recirculating blower.

Forward Distribution Bus (See figure 14).

Most of the airplane's electrical circuits are supplied current from the forward distribution bus. The circuits are protected by circuit breakers to which the forward distribution bus is attached, in the main circuit breaker panel. To energize the forward distribution bus, close either or both the "DC LOAD NO. 1" and "DC LOAD NO. 2" switches, on the overhead switch panel. Closing the load switch or switches will operate the forward distribution bus relays, located in the left hand distribution panel, and will connect the forward distribution bus to the generator bus through a 150 ampere fuse. Refer to Chapter 26 for wiring diagrams.

Emergency Bus.

The emergency bus installed in the pilot's circuit breaker panel, to which two circuit breakers are attached, supplies current to the water injection pump circuit, and the water injection control circuit. The emergency bus is energized directly from the forward distribution bus.

Interphone Bus.

The interphone bus is installed in the radio junction box at the circuit breaker panel. The "OBS. AUDIO SELECTOR", "INTERPHONE AMP." and the "JCT. BOX LTS." circuit breakers are attached to the bus. The interphone bus is energized from the forward distribution bus through the "INTERPHONE SELECTOR" circuit breaker, located on the main circuit breaker panel.

Essential Bus.

The essential bus, installed in the pilot's circuit breaker panel to which the circuit breakers are attached, is energized from the generator bus.

Hostess Bus (See figure 15).

The hostess bus installed in the hostess control panel, to which circuit breakers are attached, will supply current to the following circuits; cabin temperature indicator, cabin overhead lights, cabin night lights, aft attendant reading light, ramp lights, lavatory lights and the razor outlet. The hostess bus is energized from the left hand distribution bus. The 2 ampere "HOSTESS BUS" circuit breaker on the main circuit breaker panel will energize the 50 ampere hostess bus remote control circuit breaker, located in the left hand distribution panel and will close the circuit from the left distribution bus to the hostess bus.

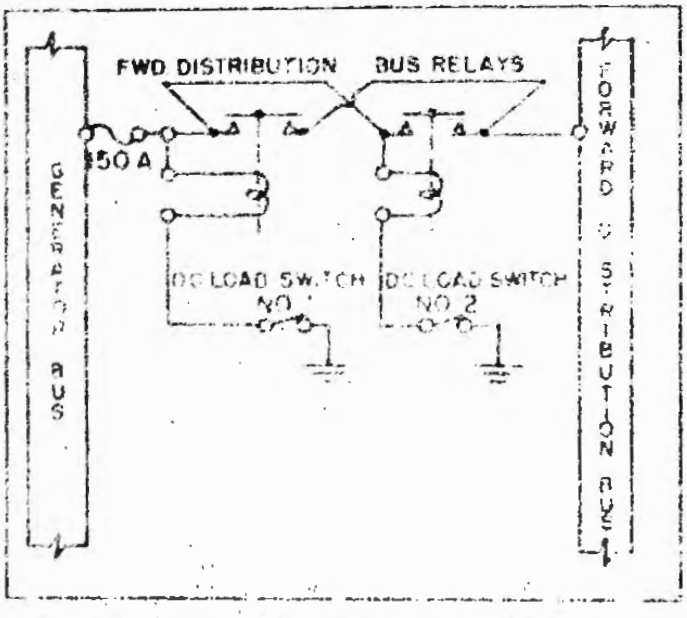


Figure 14. D-C Power Forward Distribution Bus Schematic

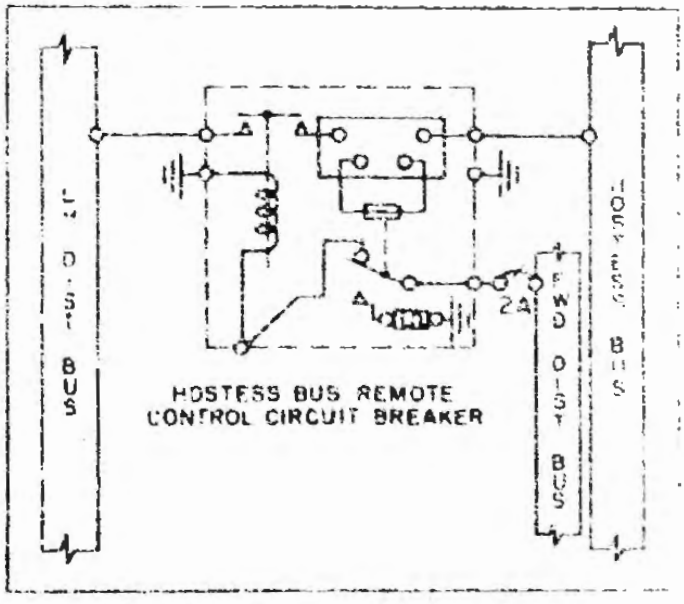


Figure 15. Hostess Bus Schematic

Monitored Bus (See Figure 16A)

The monitored bus installed at the lower left hand corner of the main circuit breaker panel supplies power through circuit breakers to the following electrical circuits; left hand combustion air blower, left hand recirculating fan, left hand cabin heating control, and galley power control.

The monitored bus cannot be energized by the battery power source. A generator or an external power source will be needed. The external power will close the external power control relay, or a generator operating will close its respective monitored bus control relay, completing the ground circuit to the "MON. BUS" switch, on the overhead switch panel. The "MONITORED BUS CONT." circuit breaker, rated at 5 amperes, on the main circuit breaker panel, will allow current to flow from the forward distribution bus through the coil of the monitored bus relay located in the main circuit breaker panel. Place the monitored bus switch to the "MON. BUS" position. This will complete the circuit and actuate the relay. Current will then flow from the forward distribution bus through the "MONITORED BUS" circuit breaker rated at 35 amperes and located on the main circuit breaker panel, through the relay contacts to the monitored bus.

Modified Monitored Bus Control System (See Figure 16)

This feature requires both generators to be operating to energize the monitored bus. The monitored bus relay will close if both generators are operating by completing a ground circuit through respective monitored bus control relays. A "MON. BUS O'RIDE" switch is located on the overhead electrical panel to provide a means of placing the monitored bus back on the line if necessary. This switch is safety wired in the "OFF" position. with No. 24 copper wire.

Radio Bus

The radio bus is located in the radio junction box and is attached to the circuit breakers which under normal condition will supply current to various radio circuits. The radio bus is energized from the generator bus, through an 80 ampere fuse and the radio bus control relay, in the right hand distribution panel. The radio bus control relay is energized from the generator bus with the ground circuit of the relay being controlled by the "RADIO" switch on the overhead switch panel.

Essential Radio Bus

The essential radio bus is installed in the radio junction box and is attached to the circuit breakers, which under emergency conditions would be essential to flight. The essential radio bus is energized from the essential bus, through the "ESS. RADIO BUS" circuit breaker, on the Pilot's circuit breaker panel, to the "ESSENTIAL RADIO" control switch on the overhead switch panel. Refer to Chapter 26 for wiring diagrams.

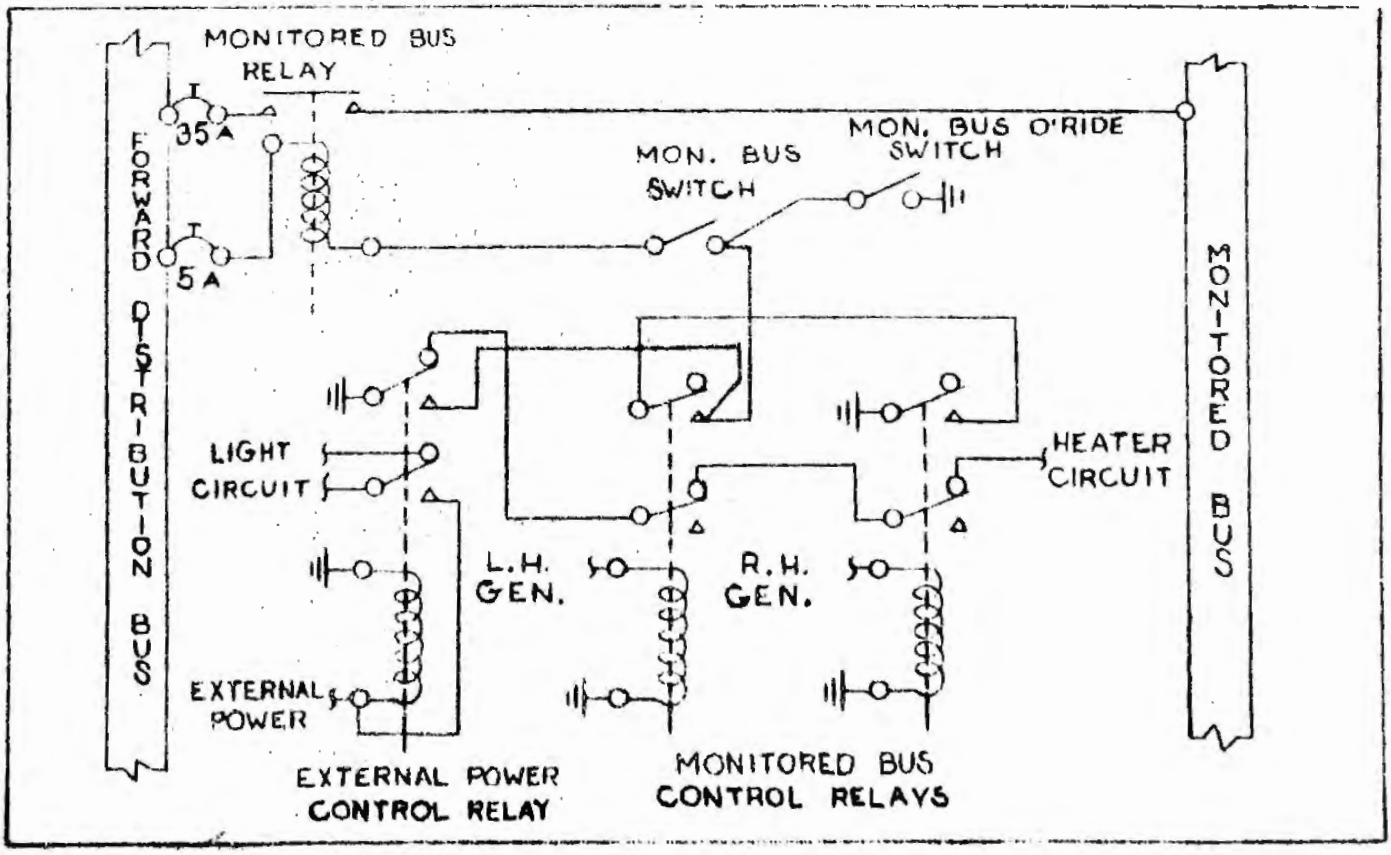


Figure 16

Left Nacelle Bus (See Figure 17).

The left nacelle bus is installed in the left nacelle junction box, and is attached to the left hand prop control relay and the left hand starter relay. The nacelle bus is energized from the generator bus, through a 200 ampere fuse and a remote control circuit breaker, located in the left hand distribution panel. Starting the left engine or actuating the left propelled control circuit, manually or automatically, will energize the remote control circuit breaker through the "L.H. NAC. BUS POWER" circuit breaker on the pilot's circuit breaker panel.

Right Nacelle Bus (See figure 17).

The right nacelle bus is installed in the right nacelle junction box and is attached to the right hand prop control relay and the right hand starter relay. The nacelle bus is energized from the generator bus, through a 200 ampere fuse and a remote control circuit breaker located in the right hand distribution panel. Starting the right engine or actuating the right propeller control circuit, manually or automatically will energize the remote control circuit breaker through the "R.H. NAC. BUS POWER" circuit breaker on the pilot's circuit breaker panel.

The right nacelle bus and its interconnections are identical to the schematic showing the left nacelle bus electrical circuit.

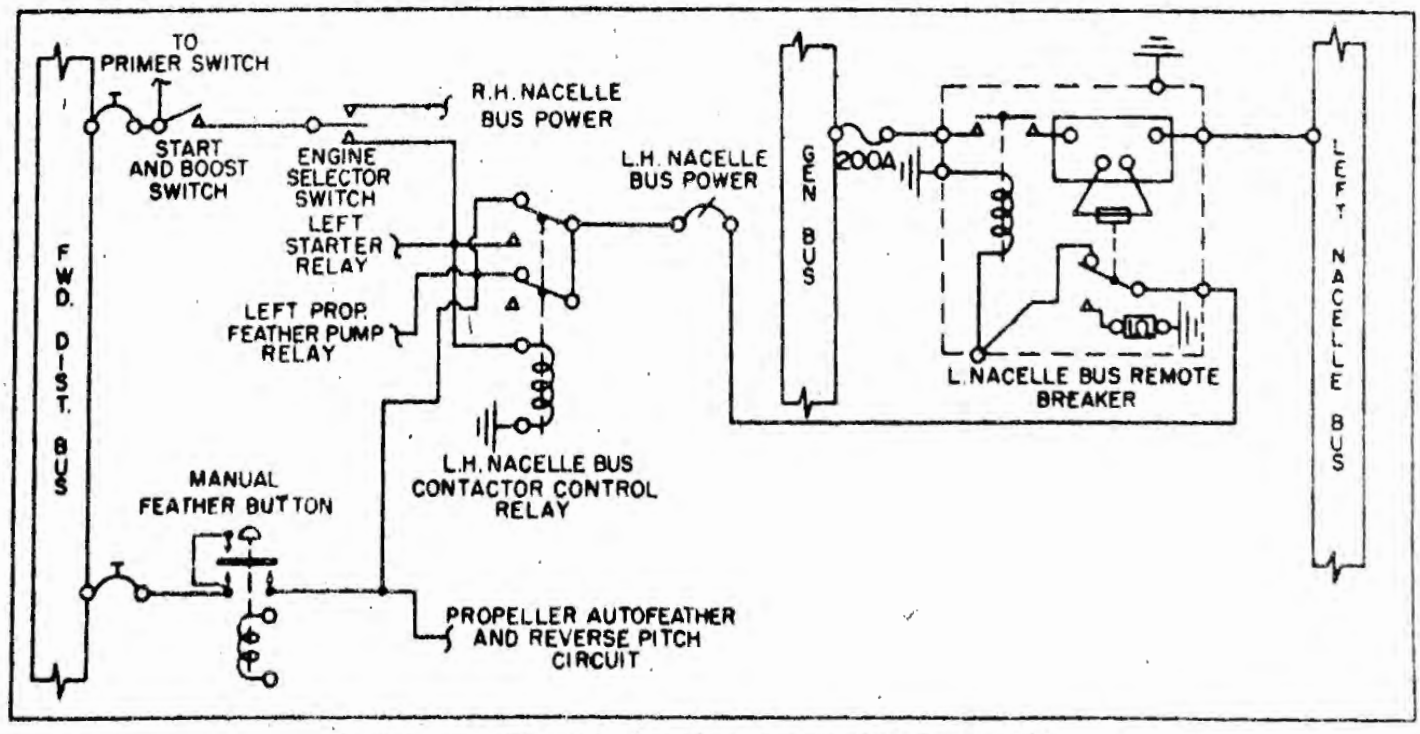


Figure 17. Right and Left Nacelle Bus Schematic

Galley Bus (See figure 18).

The galley bus located in the galley switch panel supplies current through the circuit breakers, on the panel, to the various food jugs, casseroles, and hot cup outlets. The galley bus is energized from the right hand distrubution bus. The "GALLEY CONTROL" circuit breaker, on the main circuit breaker panel is fed by the monitored bus, which will energize the galley remote control circuit breaker, located in the right hand distribution panel, and will close the circuit from the right hand distribution bus to the galley bus.

Sectionalized Bus System Remote Control Circuit Breakers (See figure 19).

There are four remote control circuit breakers used in the sectionalized bus system. They are operated electrically by control switches and circuit breakers and are used to protect the "HOSTESS BUS", "GALLEY BUS", "LEFT HAND NACELLE BUS" and "RIGHT HAND NACELLE BUS" Each remote control circuit breaker has a built-in thermal trip unit, connected to a single-pole double-throw switch. Should a fault occur or an overload exist on the busses mentioned above, the thermal trip unit would cause the switch to open. Thus opening the control circuit to the coil of the remote control circuit breaker, which in turn would open the power circuit contacts of the remote control circuit breaker and isolate the defective bus. When the thermal trip unit has caused the switch to open the control circuit, the switch makes contact through a one ohm resister to ground. Thus the control circuit is shorted out and will cause its respective control circuit breaker to trip to the "OFF" position. Therefore it will be necessary to reposition the circuit breaker to the "ON" position when the fault or overload condition has been corrected and power is to be resumed through the remote control circuit breaker. No service is necessary for the operation of this remote control circuit breaker other than periodical inspection of the power contacts.

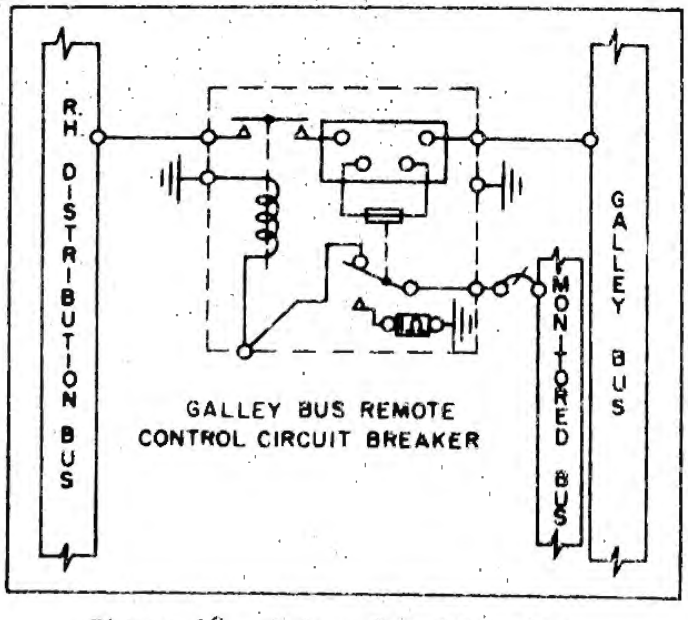


Figure 18. Galley Bus Schematic.

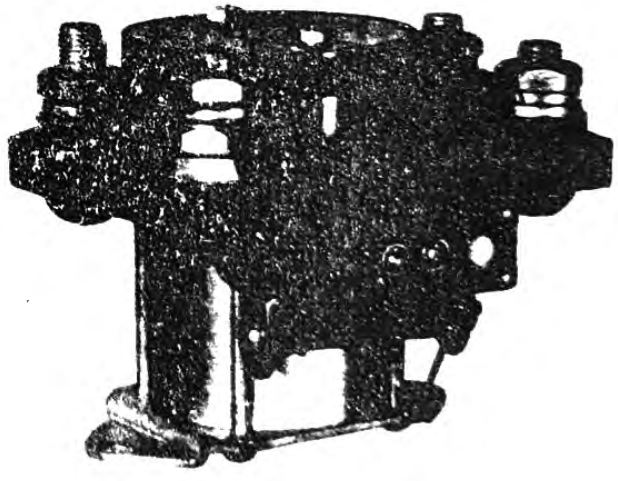


Figure 19. Sectionalized Bus System Remote Control Circuit Breaker.

A-C POWER SYSTEM - GENERAL.

The a-c power system of the airplane consists of a 115 volt, 3 phase, 400 cycle power circuit; a 115 volt single-phase, 400 cycle power circuit; a 26 volt, 3 phase, 400 cycle power circuit and a 26 volt, single-phase, 400 cycle power circuit. The a-c power system inverters are supplied with d-c power from the generator bus.

Operation Of A-C Power System.

The a-c power in the airplane is supplied by two inverters located in the forward part of the belly electrical hatch and are accessible by opening the electrical hatch door. The inverters also serve as a standby for each other in case of an a-c power failure. The a-c distribution system is located in the radio junction box, where the a-c distribution busses, transformers, circuit breakers, fuses and inverter isolation relays are installed. Single wire, ground return a-c circuits are used for communicating equipment and instruments as necessary. Structural ground returns are used on a-c circuits where the 400 cycle, common ground currents do not affect the operation of other equipment, such as the flux gate compass, interphone and audio output circuits. The overhead switch panel contains the "INVERT" master control switch and the "INVERTER SELECTOR" switch. Located on the pilot's and co-pilot's instrument panels are the A-C Power Failure indicators, which indicates insufficient a-c power output of either inverter. Located near the A-C Power Failure indicators on the panels are the "A-C POWER" inverter - alternator switches, which when in the "NORMAL" position closes the a-c power circuits from their respective flight instrument transformer to their respective Turn and Bank, Gyro Horizon and A-C Power Failure indicators. The "EMERG" position of the "A-C POWER" switch closes the a-c power circuit from their respective engine driven alternators to the essential-to-flight indicators. The pilot'a console panel contains the "A-C VOLTMETER" and two position voltage phase selector switch. The inverters supply a-c power for the following circuits:

Radio circuits; 115 volt, 1-phase, 400-cycles.
Gyro Horizon Indicators, Turn and Bank Indicators, and A-C Power Failure Indicators; 26-volt, 3-phase, 400-cycles.
Engine Instruments; 26-volt, 1-phase, 400-cycles.
Radio circuits; 26-volt, 1-phase, 400-cycles.

The engine driven alternators supply 26 volt, 3 phase, 400 cycles a-c power for the following circuits in an emergency, Gyro Horizon Indicators circuit, Turn and Bank Indicators circuit, and the A-C Power Failure Indicators circuit.

A-C POWER INVERTER CIRCUIT (See figure 25).

The a-c power inverter circuit consists of the following pieces of equipment. Location of each piece is shown.

EQUIPMENT	LOCATION
Inverters	Forward side, in electrical access hatch #84.
A-C Distribution Busses	Radio junction box.
Transformers	Radio junction box.
Inverter Isolation Relays	Radio junction box.
Pilot's A-C Bus	Radio junction box.
Co-Pilot's A-C Bus	Radio junction box.
A-C Power Fuses And Circuit Breakers	Radio junction box.
"Autosyn Power 26V" Switches	Radio junction box.
Inverter D-C Power Fuses	Center distribution panel, in electrical access hatch #84.
"INVERT" Master Control Switch	Overhead switch panel.
"INVERTER SELECTOR" Switch	Overhead switch panel.
"A-C POWER" Switches	Pilot's and co-pilots' instrument panels.
A-C Power Failure Indicators	Pilots' and co-pilots' instrument panels.
A-C Voltmeter And Phase Selector Switch	Pilots' console panel.
Alternators	Left and right engine accessory section.

Operation Of A-C Power Inverter Circuit. (See figure 25).

With a 28 volt d-c power source supplying the generator bus and the "INVERT" master control switch, located on the overhead switch panel, in the "NORMAL" position, power is available at the "INVERTER SELECTOR" switch. Place the "INVERTER SELECTOR" switch in the "EAST" position, this will start the left inverter and energize the left inverter isolation relay. Place the "INVERTER SELECTOR" switch in the "WEST" position, this will start the right inverter and energize the right inverter isolation relay.

NOTE: The selector switch must not be opened within a period of five (5) seconds after closing the switch nor should the inverter be switched on and off more than twice in one (1) minute, or more than fifteen (15) times in one hour.

Either inverter when operating will supply the A and C phase busses through the contacts of the isolation relay. The A and C phase busses feed various circuits, transformers and the "A-C VOLTMETER", all of which are protected by fuses and circuit breakers located in the radio junction box control panel. Failure of either in

Operation of A.C. Power Inverter Circuit (Cont.)
(See Figure 25)

...ter to supply the essential-to-flight indi... will be indicated by the a-c Power Fail... Indicators on the pilot and co-pilot's in... ument panels. Switching the "A-C POWER" ...itches from "NORMAL" position to "EMERG" posi...ion permits the engine driven alternators to ...upply the essential-to-flight indicators.

Inverters (See figure 20).

There are two 115 volt a-c, 400 cycle inverters, each rated 15 V.A. single phase or 2000 V.A. three phase and are located in the Electrical Access Hatch #84. They are installed on shock mounted base assemblies having quick disconnect mounting fasteners with the forward inboard and the aft outboard fasteners requiring the safety wiring, on each inverter. The inverters operate at 12,000 r p m with a 28 volt d-c input, and will supply a 115 volt, 1 phase, 400 cycle and a 115 volt, 3 phase, 400 cycle a-c output. There is an a-c frequency control and an a-c voltage regulation control built into each inverter. A filter is built into each inverter to reduce radio interference. Cooling is accomplished by openings in the control panel cover and through the vent holes of the inverter casing. The fan of the inverter circulates the air (See figure 27).

Inverter Isolation Relays.

Each inverter circuit has a double-pole, double-throw isolation relay installed in the radio junction box. The relay is controlled by the inverter selector switch, and when energized, completes the circuit from the inverter output to the a-c distribution busses.

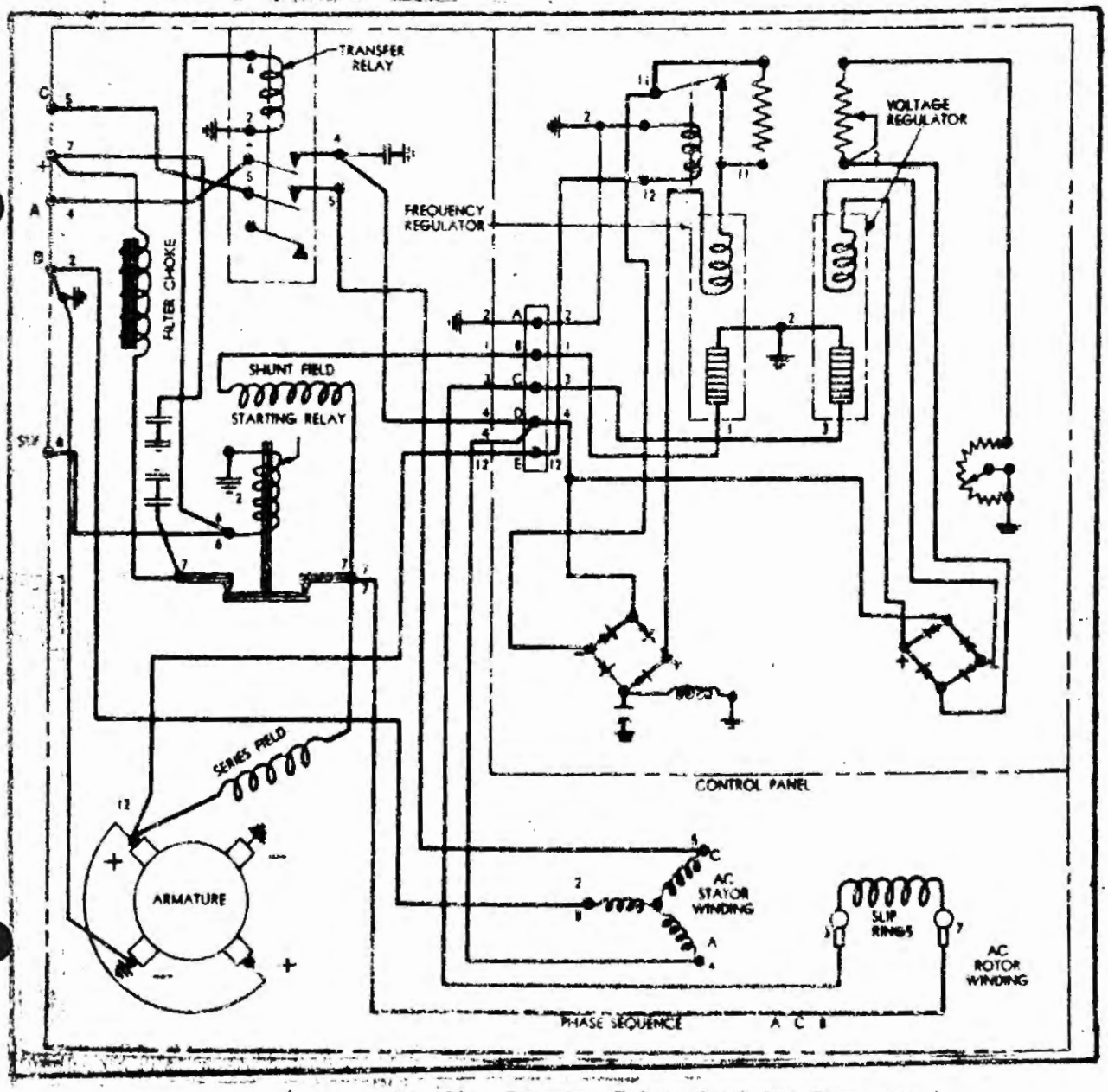


Fig. 20. Inverter Internal Wiring Schematic

A-C Distribution Busses.

There are two 115 volt, 3 phase, 400 cycle, a-c distribution busses located in the radio rack. When either inverter is operating, one bus is energized by "A" phase, the other bus by "C" phase of the inverter. These busses are used to distribute a-c power to step-down transformers and circuits using 115 volts a-c power. The busses are protected by fuses and circuit breakers (See figure 25).

Flight Instrument Transformers.

There are two 115 volt to 26 volt, 3 phase, 400 cycle transformers installed in the radio junction box. One transformer supplies 26 volt, 3 phase, 400 cycle, a-c power to the pilot's flight instruments, gyro horizon, turn and bank and the a-c power failure indicators. The other transformer will supply the co-pilot's flight instruments. These transformers are fed from the a-c distribution busses.

Instrument Transformers.

There are two 115 volt to 26 volt, 1 phase, 400 cycle instrument transformers installed in the radio junction box. The "PILOT 26V. A-C INSTR. TRANSF." and the "CO-PILOT 26V. A-C INSTR. TRANSF." are supplied 115 volts a-c power from the C phase bus through the "26 VOLT TRANSF. PILOT" and "CO-PILOT" fuses located on the radio junction box control panel. These transformers supply 26 volt a-c power to their respective pilot's or co-pilot's bus which feeds through fuses numerous indicating circuits as shown on Figure 25.

Radio Transformers

Two 115V to 26V 1 phase 400 cycle transformers are located in the radio junction box. Each transforme receives 115V AC supply from the "A" phase of the inverter power supply through a 1 ampere fuse. A "NORMAL"- EMERGENCY" switch on the radio junction box provides a means of switching from one transformer to the other.

"AUTOSYN POWER TRANSFORMERS".

There are two 115 volt to 26 volt, 1 phase, 400 cycle "AUTOSYN POWER TRANSFORMERS" located in the radio junction box. The "NORMAL" and stand-by "EMERGENCY" transformers are supplied 115 volt a-c power from the A phase bus through the "AUTOSYN POWER NORMAL" and "EMERG" fuses located on the radio junction box control panel. These transformers are controlled by the dual "AUTOSYN POWER 26V." switches located on the radio junction box control panel, and supply 26 volt a-c power through fuses to various radio circuits as shown on Figure 25. Refer to Chapter 27 for text on radio circuits and Chapter 26 for wiring circuitry.

"AUTOSYN POWER 26V." Switches.

The two "AUTOSYN POWER 26V." switches, barred together and located on the radio junction box control panel are of the double-pole, double-throw type having a "NORMAL" and a "EMERG." position. The "NORMAL" position closes the 26 volt a-c power output circuit from the "NORMAL AUTOSYN POWER TRANSFORMER" to the radio bus which feeds various radio circuits through fuses as shown on Figure 25. The "EMERG" position closes the 26 volt a-c power output circuit from the "EMERGENCY AUTOSYN POWER TRANSFORMER" to the radio bus.

"A-C POWER" Switches.

There are two "A-C POWER" switches, one installed on the pilot's instrument panel, the other on the co-pilot's instrument panel. Normally the switches are placed to the "NORMAL" position, and either inverter will supply alternating current to the pilot's and co-pilot's Gyro Horizon Indicators, Turn and Bank Indicators and both A-C Power Failure Indicators. In the event of a failure of both inverters, the switches should then be placed to the "EMERGENCY" position. This will complete the circuit for the left engine driven alternator to supply a-c power to the pilot's flight instruments, and the right engine driven alternators to supply a-c power to the co-pilot's flight instruments.

"INVERT." Master Control Switch (See figure 3).

The inverter master control switch on the overhead switch panel will de-energize either inverter that may be operating, should an emergency condition arise and the "EMERGENCY LOAD REDUCTION" actuator be pressed to the down position. Normally this switch is left in the "NORMAL" position.

"INVERTER SELECTOR" Switch (See figure 3).

This selector switch is for individual inverter selection and is installed on the overhead switch panel. When the switch is placed in the "EAST" position, and the inverter master control switch is in the "NORMAL" position, a circuit will be completed from the generator bus to the coil of the internal starting relay, in the inverter housing, and to the coil of the inverter isolation relay, thus starting the left inverter which will then supply a-c power to the a-c distribution buses. When the selector switch is placed to the "WEST" position, the right inverter will supply a-c power to the a-c distribution buses.

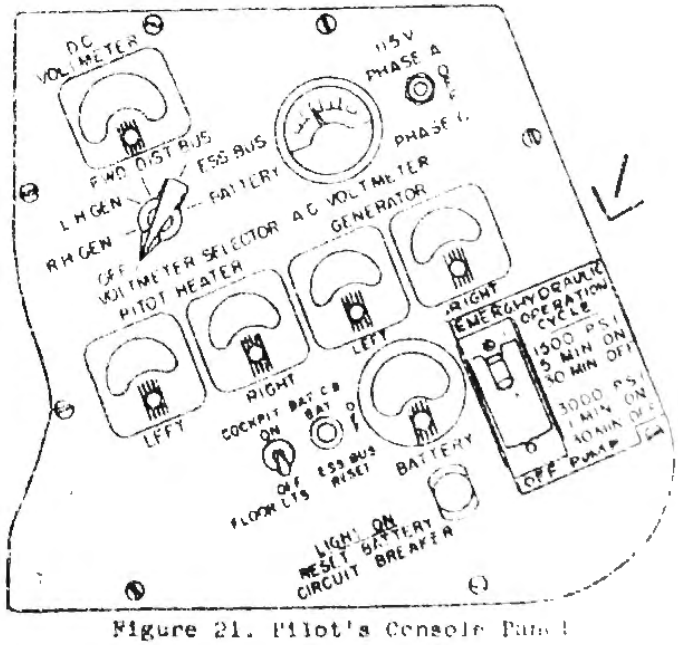


Figure 21. Pilot's Console Panel

A-C Voltmeter and Phase Selector Switch (See Figure 23).

An "A-C VOLTMETER" and a "PHASE A and PHASE C" selector switch is installed on the pilot's console panel to indicate the amount of voltage being supplied by the inverters to the "A" and "C" phase distribution busses.

A-C Power Failure Indicators.

There are two a-c instrument power failure indicators, installed on the pilot's and co-pilot's instrument panels close to the gyro horizon and turn and bank indicators. The indicators will show a luminous [illegible] when the a-c power circuit is not in operation or when the a-c power circuit is in operation and the voltage to the indicator is below 18 volts. The indicator will show a black indication when a-c power output is above 22 volts denoting sufficient a-c power is supplying the essential to flight indicators.

Pilot's A-C Bus.

The pilot's bus, installed in the radio junction box, is energized by a 26 volt, 1 phase, feeder from the pilot's instrument transformer. This bus distributes a-c power to transmitters and to one side of the dual indicators for the left engine, and also to transmitters and single indicators. Fuses installed on the radio junction box panel, protects the pilot's bus which energizes the following circuits:

Hydraulic Pressure Indicator (main system)
Wing Flap Position Indicator
Torque Pressure Indicator
Oil Pressure Indicator
Manifold Pressure Indicator
Fuel Pressure Indicator
Oil Quantity Indicator
ADI Water Pressure Indicator
Fuel Flow Indicator

Co-Pilot's A-C Bus.

The co-pilot's bus installed in the radio junction box is energized by a 26 volt, 1 phase, feeder from the co-pilot's instrument transformer. This bus distributes a-c power to transmitters and to one side of the dual indicators for the right engine, and also to transmitters and single indicators. Fuses installed on the radio junction box panel, protects the co-pilot's bus which energizes the following circuits:

Hydraulic Pressure Indicator (closet center)
Hydraulic Pressure Indicator (emergency brake system)
Torque Pressure Indicator
Oil Pressure Indicator
Manifold Pressure Indicator
Fuel Pressure Indicator
Oil Quantity Indicator
ADI Water Pressure Indicator
Primary Compressor Oil Pressure Indicator
Primary Compressor Oil Pressure Warning Light
Fuel Flow Indicator

Inverter A-C Power Fuses.

The four a-c power fuses installed in the [illegible] distribution panel, protect the [illegible] bus which energizes the inverter through a 200 ampere fuse. The 10 ampere fuse protects the generator bus which energizes the [illegible] circuit of the inverter. The left and right inverter have individual fuses.

Operation Of A-C Power Alternator [illegible]

A third source of a-c power is provided by engine-driven alternators. The left and right alternator circuits are controlled by the "MAIN-EMERG. A-C POWER" switches located on the pilot's and co-pilot's flight instrument panels respectively. When the switch is placed in the "EMERG." position, the alternator will supply a-c power only to the gyro-horizon, turn and bank, and the a-c power failure indicators on the respective side.

Alternators (See Figure 21).

There are two engine driven alternators located in the engine accessory section, which are used as sources of standby power for the gyro horizon, turn and bank, and the a-c power failure indicators. Each alternator has an a-c output of 27 volt, 3 phase, 400 cycles power. Each alternator has a permanent magnet rotor which is driven at a 1.4 to 1 ratio to engine speed. The rotor turns counterclockwise, when facing the drive end of the alternator, and revolves in a stator which has three groups of coils connected together. A tapped lead from each coil is brought out to terminals A2, B2 and C2 for reduced power. The remaining end of each coil is connected to terminals A4, B4 and C4 for full power from each of the three phases.

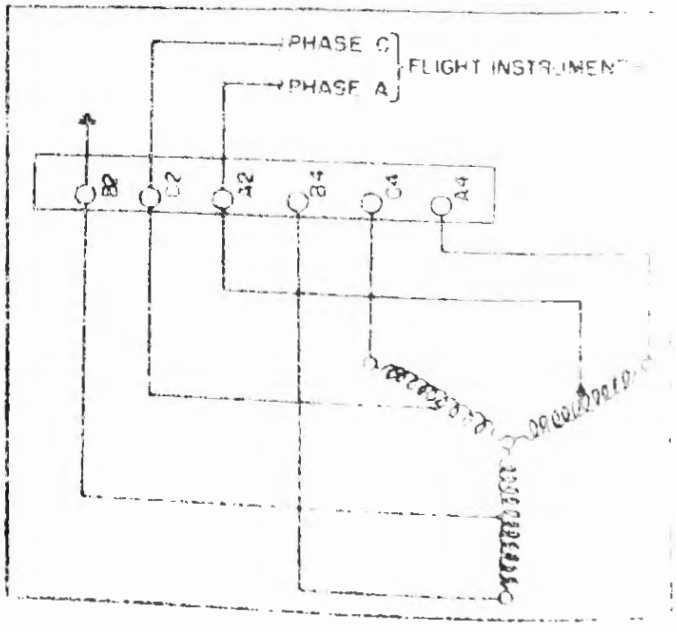


Figure 22. Alternator Internal Wiring Diagram

POWER CONTROL SWITCHES (See Figure 2)

The electrical system of the airplane has ten power control toggle switches. They are divided into DC and AC groups. The DC power switches consist of the left and right "GENERATOR" switches; "BAT.-EXT. PWR" switch; "No. 1 and No. 2, DC LOAD" switches; "RADIO" switch, "MON. BUS" switch, "MON. BUS. O'RIDE" switch and the "ESSENTIAL RADIO" switch. The AC power switches consist of the "INVERT." switch, and the "INVERTER SELECTOR" switch. The "MASTER POWER CONTROL" actuator permits emergency cut-off of both generator and battery circuits. The "EMERGENCY LOAD REDUCTION" actuator permits emergency cut-off of the "DC LOAD" switches, "INVERT " switch, "RADIO" switch and the "MON. BUS" switch. All power switches are located on the overhead switch panel in the Pilot's compartment.

Operation of Power Control Switches (See Figure 4)

The ten power and load switches on the overhead switch panel will be in the "UP" position during normal flight and ground testing. In the event smoke or fire is detected the "EMERGENCY LOAD REDUCTION" actuator, located above the "DC LOAD" switches, "INVERT." switch, "RADIO" switch and the "MON. BUS" switch, should be operated to the "EMERGENCY OFF" position momentarily. All five switches under this control will be placed in the "OFF" position. At this time both generators and the battery will continue to supply the DC power requirements of essential-to-flight and ground testing loads. The "INVERTER SELECTOR" switch should be placed in the opposite position and the "INVERT." load control switch re-established to the "NORMAL" position. The other inverter will then supply the AC requirements. Should the generator and battery power need be disconnected throughout the airplane, the "MASTER POWER CONTROL" actuator should be operated to the "DOWN" position momentarily. This will place the left and right "GENERATOR" switches and the "BAT-EXT. PWR." switch to the "OFF" positions.

The left and right "GENERATOR" switches have a momentary "RE-SET" position, which is used to reset the generator field relay. The "FIELD TRIP" lights located below the "GENERATOR" switches will be illuminated denoting the generator field relay is tripped.

The "BAT-EXT. PWR." switch has an "EXT. PWR" position to be used when an external DC power source is connected to the external power receptacle.

The "ESSENTIAL RADIO" control switch energizes the essential radio bus from the essential bus and the circuit is protected by the "ESS. RADIO BUS" circuit breaker on the Pilot's circuit breaker panel.

A-C AND D-C DISTRIBUTION PANELS - GENERAL.

The a-c and d-c distribution panels incorporated in the airplane provide a means of protection for the sectionalized bus system and the various components used in the electrical system.

A-C And D-C Distribution Panels.

The a-c and d-c distribution panels are as follows:

D-C Center Distribution Panel
D-C Left Support Panel
D-C Right Support Panel
D-C Left Distribution Panel
D-C Right Distribution Panel
Belly Circuit Breaker Box
Belly Electrical Junction Box
Pilot's Circuit Breaker Panel
Main D-C Power Circuit Breaker Panel
Station 212 Relay Panel
A-C Power Distribution Panel
Hostess Control Panel
Left Hand Nacelle Junction Box
Right Hand Nacelle Junction Box

D-C Center Distribution Panel (See figure 29).

The d-c center distribution panel is located at the center overhead aft section in the belly electrical access hatch, and is attached to the left and right support panels. The panel is made of laminated phenolic fibre and the under surface is coated with white varnish. Located on the center distribution panel is the generator bus, which is the main d-c power distribution bus used to supply the sectionalized bus system. Fuses are installed on the center distribution panel and are attached to the generator bus.

The fuses are as follows:

"INVERTER PWR. R.H." Fuse
"INVERTER PWR. L.H." Fuse
"INVERTER CONT. R.H." Fuse
"INVERTER CONT. L.H." Fuse
"D-C REG. PANEL R.H." Fuse
"D-C REG. PANEL L.H." Fuse
"NAC. BUS R.H." Fuse
"NAC. BUS.L.H." Fuse
"D-C DISTR. BUS R.H." Fuse
"D-C DISTR. BUS L.H." Fuse
"RADIO BUS" Fuse
"FWD. DIST. BUS" Fuse

The d-c reverse current electrical reset circuit breaker is also attached to the generator bus and is mounted on the center distribution panel.

A phenolic fibre cover is installed over the generator bus and fuses, and is held to the center distribution panel by four airlock thumb fasteners. Installed on the outside surface of the cover, are the spare fuses. The spare fuses consist of one 300 ampere fuse, one 200 ampere fuse, one 150 ampere fuse, one 80 ampere fuse, one 70 ampere fuse and one 10 ampere fuse.

D-C Left Hand Support Panel (See figure 29).

The d-c left hand support panel is located at the left overhead aft section in the belly electrical access hatch, and is attached to the center distribution panel and the left hand distribution panel. The panel is made of laminated phenolic fibre and the under surface is coated with white varnish. Located on the left hand support panel is the left hand generator feeder and back-up protection contactor and left engine zone 1 fire detector resistor.

D-C Right Hand Support Panel (See figure 29).

The d-c right hand support panel is located at the right overhead aft section in the belly electrical access hatch, and is attached to the center distribution panel and the right hand distribution panel. The panel is made of laminated phenolic fibre and the under surface is coated with a white varnish. Located on the right hand support panel is the right hand generator feeder and back-up protection contactor, right engine zone 1 fire detector resistor and the radio bus relay.

D-C Left Hand Distribution Panel(See figure 31).

The d-c left hand distribution panel is located on the left side in the aft section of the belly electrical access hatch, and is attached to the left hand support panel. The panel is made of laminated phenolic fibre and the inboard side is coated with a white varnish. Located on the left hand d-c distribution panel is the left hand distribution bus and the following relay, contactors and remote control circuit breakers:

"BATTERY RELAY"
"NAC. BUS. L.H." Remote Control Circuit Breaker
"HOSTESS PANEL BUS" Remote Control Circuit Breaker
"FUEL BOOSTER PUMP L.H." Remote Control Circuit Breaker
"FWD. DIS. BUS" Contactors (2)
"LANDING LIGHT L.H." Remote Control Circuit Breaker
"AIRSCOOP BLANKET" Remote Control Circuit Breaker
"RECIRCULATING AIR BLWR. L.H." Remote Control Circuit Breaker

D-C Right Hand Distribution Panel (See figure 33).

The d-c right hand distribution panel is located on the right side in the aft section of the belly electrical access hatch, and is attached to the right hand support panel. The panel is made of laminated phenolic fibre and the inboard side is coated with a white varnish. Located on the right hand distribution panel is the right hand distribution bus and the following relays and remote control circuit breakers:

"EXTERNAL POWER" Relay
"A.D.I." Relay
"NAC. BUS R.H." Remote Control Circuit Breaker

D-C Right Hand Distribution Panel (Cont.).

"LANDING LIGHT R.H." Remote Control Circuit Breaker
"FUEL BOOSTER PUMP R.H." Remote Control Circuit Breaker
"EMERG. HYD. PUMP" Remote Control Circuit Breaker
"RECIRCULATING AIR BLWR. R.H." Remote Control Circuit Breaker
"GALLEY" Remote Control Circuit Breaker

Belly Circuit Breaker Box (See figure 35).

The belly circuit breaker box is installed on the forward overhead section in the belly electrical access hatch. The box houses the right and left generator circuit ballast resistors. The face of belly circuit breaker box contains the four generator ballast lamps and the following circuit breakers:

"BATTERY RELAY CONTROL" Circuit Breaker
"BATTERY RESET CONTROL" Circuit Breaker
"LEFT GEN. CONTROL" Circuit Breaker
"RIGHT GEN. CONTROL" Circuit Breaker

Belly Electrical Junction Box (See figure 37).

The belly electrical junction box is located in the aft section of the aft heater access hatch. The belly junction box is used to house the anti-icer heater timer, five resistors and one rectifier for the fire warning system and two resistors for the left and right generator field reset relay circuit. The following relays and rectifier are also installed in the belly junction box:

"HEATER CUT-OFF RELAY L.H."
"HEATER CUT-OFF RELAY R.H."
"CABIN HEATER CONTROL RELAY L.H."
"CABIN HEATER CONTROL RELAY R.H."
"L.H. MONITOR BUS CONTROL" Relay
"R.H. MONITOR BUS CONTROL" Relay
"L.H. GENERATOR FIELD RESET" Relay
"R.H. GENERATOR FIELD RESET" Relay
"EXTERNAL POWER CONTROL" Relay
"REGULATOR JACKS CONTROL RELAY"
"L.H. FIRE DETECT. WARNING BELL RELAY"
"R.H. FIRE DETECT. WARNING BELL RELAY"
"EXT. POWER RECTIFIER"

Two covers are installed on the front of the belly junction box and are secured by Airloc thumb fasteners. The right hand cover has a hole near the top side, which is used for visibility to the anti-icer heater timer.

Pilot's Circuit Breaker Panel (See figure 39).

The pilot's circuit breaker panel is located on the forward left hand side of the bulkhead at station 212. Access to the rear of the panel is made possible by removing the top cover above the main circuit breaker panel on the aft left side of station 212. Attached to the "WATER INJECTION PUMP" circuit breaker and the "WATER INJECTION PUMP" circuit [illegible] the 28 volt d-c emergency bus. The remaining circuit breakers are attached to the 28 volt d-c essential bus. Mounted in the compartment back of the pilot's circuit breaker panel, is the "L.H. NAC. BUS PWR." relay, "R.H. NAC. BUS PWR." relay and the "A-C VOLTMETER PROTECTION" fuse. The a-c voltmeter fuse are accessible on the top side of the compartment. (See figure 41).

Main D-C Power Circuit Breaker Panel. (See figure 43).

The main d-c power circuit breaker panel is located on the aft left hand side at station 212 bulkhead. Access to the circuit breaker panel is made by opening the hinged cover installed over the face of the circuit breaker panel. The panel contains numerous circuit breakers used in the "EXTERIOR LTS." circuits, "INTERIOR LTS." circuit, "HEATING & VENTILATING" circuits, "ENGINE CONTROLS" circuits, "ENGINE INSTRUMENTS" circuits, "WARNING DEVICES" circuits and "MISCELLANEOUS" circuits. The circuit breaker panel is hinged at the inboard side and may be opened, by unfastening the nine Airloc fasteners on the top, bottom and outboard side, on the face of the panel.

The 28 volt d-c forward distribution bus is attached to all the circuit breakers on the main circuit breaker panel except the "L.H. HEATER CONTROL", "L.H. COMB. AIR BLOWER", "L.H. RECIRCULATING FAN" and the "GALLEY CONTROL" circuit breakers. The 28 volt d-c monitored bus is attached to the four circuit breakers mentioned above. (See figure 45).

Station 212 Relay Panel (See figure 47).

The station 212 relay panel is located directly below the main circuit breaker panel on the aft left side of station 212 bulkhead. Access to the relay panel is made by removing the cover of the relay panel compartment. The following relays are installed on the panel:

"CABIN HEATER CUT-OFF" Relay
"MONITOR BUS" Relay
"SIGNAL LIGHT" Relay
"L.H. COMBUSTION AIR BLOWER" Relay
"R.H. COMBUSTION AIR BLOWER" Relay

A-C Power Distribution Panel (See figure 55).

The a-c power distribution panel is located on the aft bottom side of the radio. Access to the a-c panel is made by removing the aft bottom cover on the radio junction box. The a-c distribution panel houses the following components:

Right Hand Inverter Isolation Relay
Left Hand Inverter Isolation Relay
Co-Pilot's 26 Volt A-C Instrument Transformer
Pilot's 26 Volt A-C Instrument Transformer
Co-Pilot's 26 Volt A-C Flight Instrument Transformer
Pilot's 26 Volt A-C Flight Instrument [illegible]
[illegible] Volt A-C [illegible]
Autosyn [illegible]

A-C Power Distribution Panel (Cont'd)

115 Volt A-C Power "C" Phase Bus
Pilot's 26 Volt A-C Power Bus
Co-Pilot's 26 Volt A-C Power Bus

The radio junction box panel contains the various fuses and circuit breakers used in the a-c power circuits.

Hostess Control Panel. (See figure 49).

The hostess control panel is installed on the upper forward section of the aft carry-on baggage rack. Revealed on the face of the panel is the "TEMP. CONTROL" selector, "CABIN TEMP." indicator and the following switches & circuit breakers.

"HOSTESS READING LIGHT" Switch
"COAT ROOM LIGHT" Switch
"CABIN NIGHT LIGHT" Switch
"CARGO COMPT. LIGHTS" Switch
"RAMP LIGHT" Switch
"CABIN OVERHEAD LIGHT" Switch
"CABIN O.H. LIGHTS" Circuit Breaker
"HOSTESS SERVICE LTS." Circuit Breaker
"RAMP LIGHTS" Circuit Breaker
"CABIN NIGHT LTS." Circuit Breaker
"LAVATORY SIGN" Circuit Breaker
"CABIN TEMP. IND." Circuit Breaker
"CALL PILOT" Switch
"ACKNOWLEDGE PILOT CALL" Switch
"ACKNOWLEDGE LAV. CALL" Switch
"CHIME CUT-OFF" Switch
"RAZOR OUTLET" Circuit Breaker
→ "VEST. LIGHT" Switch

Installed on the aft side of the hostess control panel and attached to the circuit breakers, is the 28 volt d-c hostess bus. A chime is also installed on the aft side of the panel at the chime grill. The compartment back of the hostess control panel houses the following relays: (See figure 51)

"PILOT CALL RELAY"
"STAB. ACTUATOR EXTEND RELAY"
"CHIME RELAY"
"STAB. ACTUATOR RETRACT RELAY"
"CABIN OVERHEAD LIGHTS RELAY"
"STAB. ACTUATOR FIELD REVERSING" Relay
"LAVATORY CALL RELAY"

Left Hand Nacelle Junction Box. (See figure 53).

The left hand nacelle junction box is located at the forward inboard section in the left hand main-gear wheel well nacelle. The left hand nacelle junction box is used to house the following components of the electrical system;

Left Hand Nacelle Bus
Left Hand Generator Shunt
Left Hand Generator "GND. AND FEEDER PROTECTION RELAY"
"GENERATOR ISOLATION RELAY"
"STARTER RELAY"
"L.H. PROP. FEATHER PUMP RELAY"

Access to the components in the nacelle box is made by unfastening the nine airloc thumb fasteners holding the cover to the box assembly.

Right Hand Nacelle Junction Box. (See figure 53)

The right hand nacelle junction box is located at the forward outboard section in the right hand main gear wheel well nacelle. The right hand nacelle junction box is used to house the following components of the electrical system:

Right Hand Nacelle Bus
Right Hand Generator Shunt
Right Hand Generator "GND. AND FEEDER PROTECTION RELAY"
"GENERATOR ISOLATION RELAY"
"STARTER RELAY"
"R.H. PROP. FEATHER PUMP RELAY"

Access to the components in the nacelle box is made by unfastening the nine airloc thumb fasteners holding the cover to the box assembly.

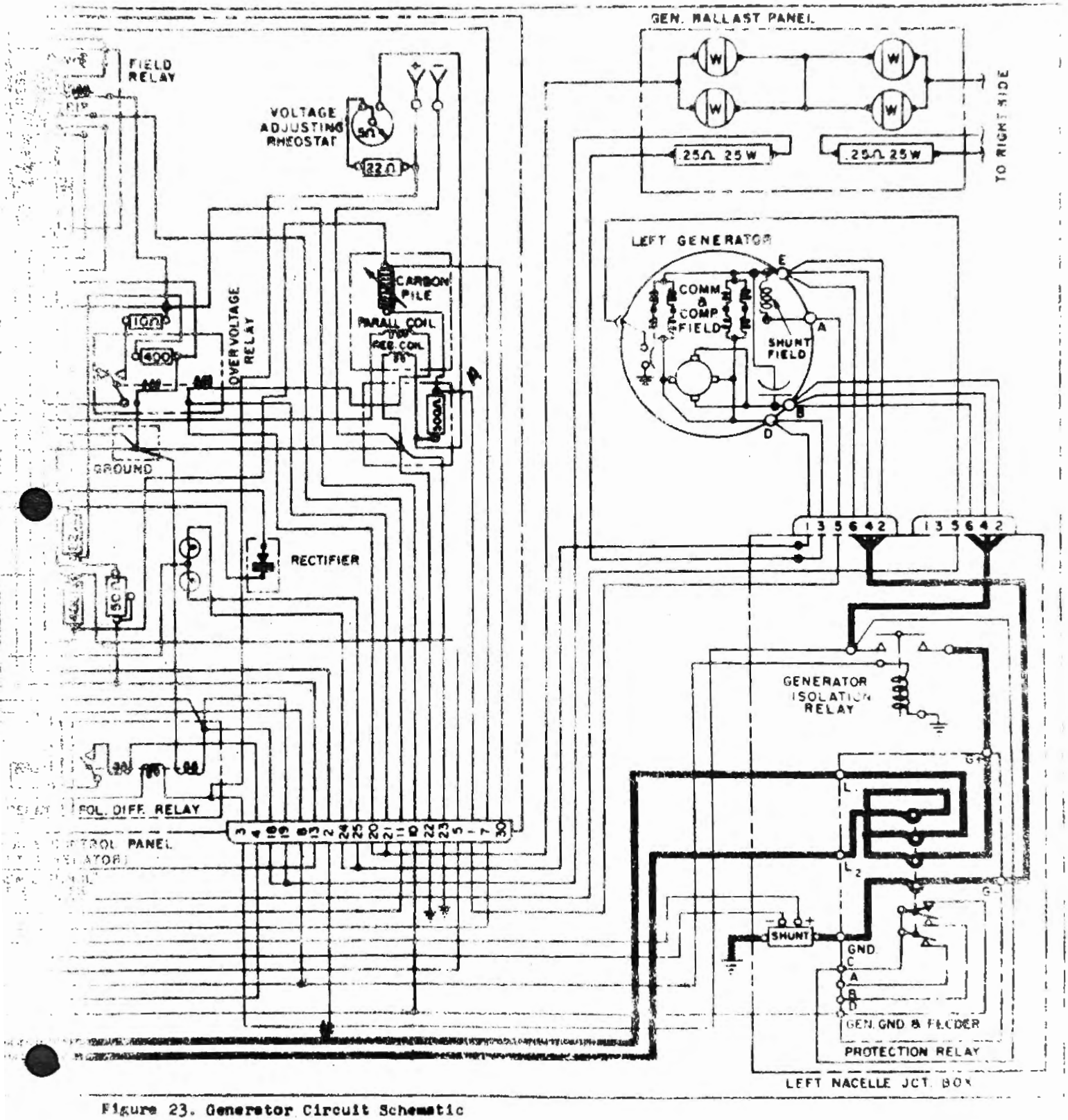


Figure 23. Generator Circuit Schematic

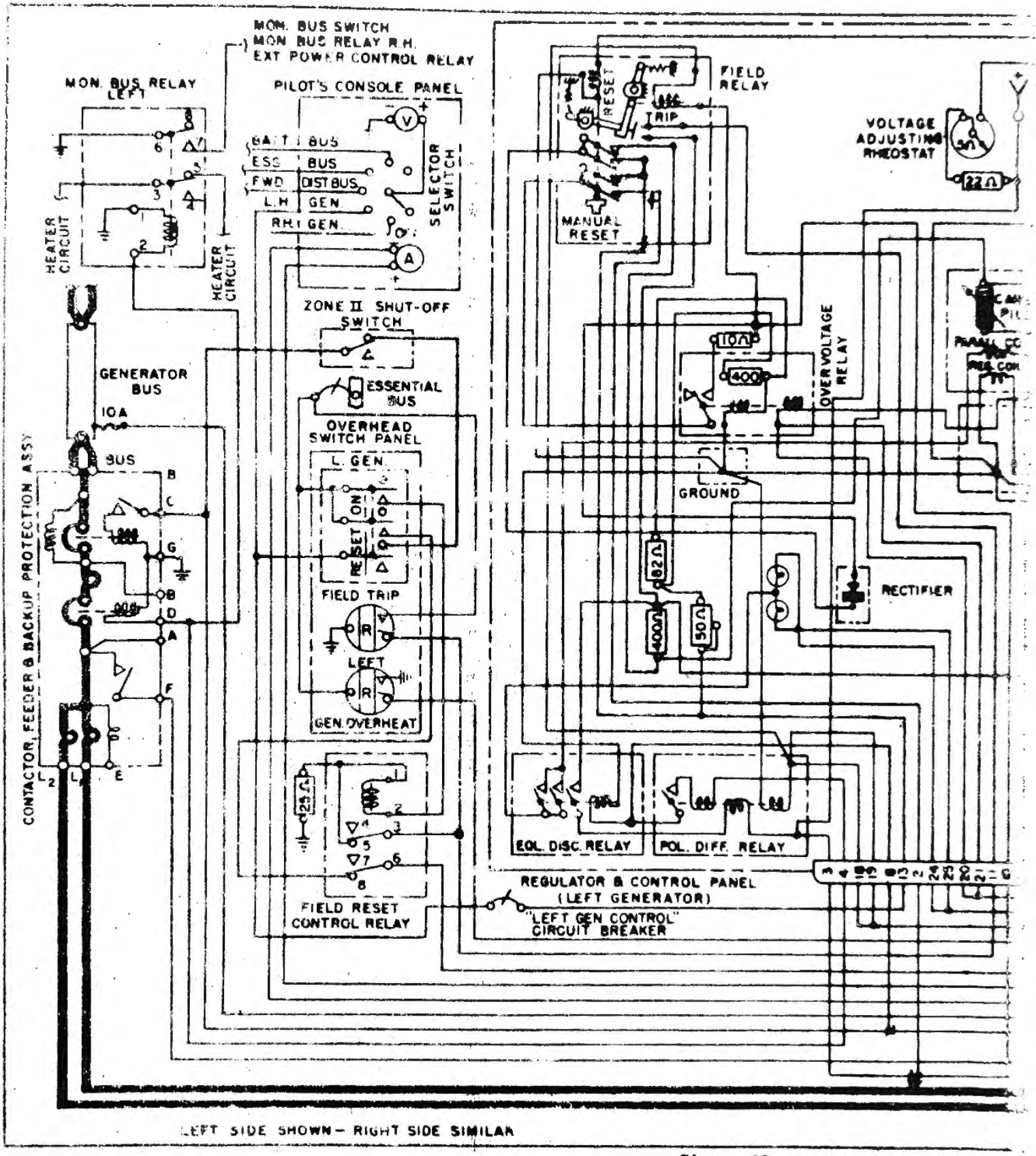


Figure 23. Generator Circuit Schem

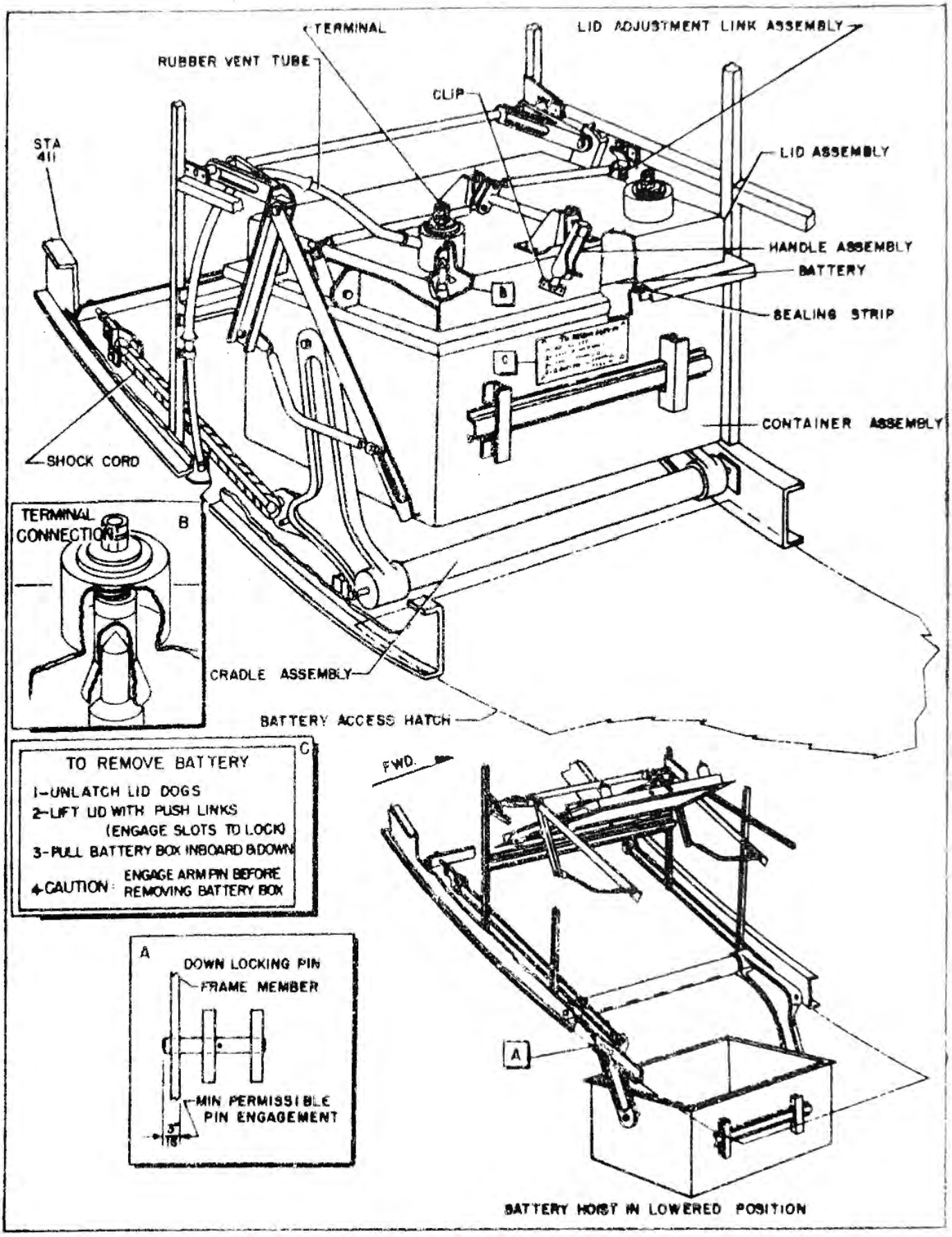
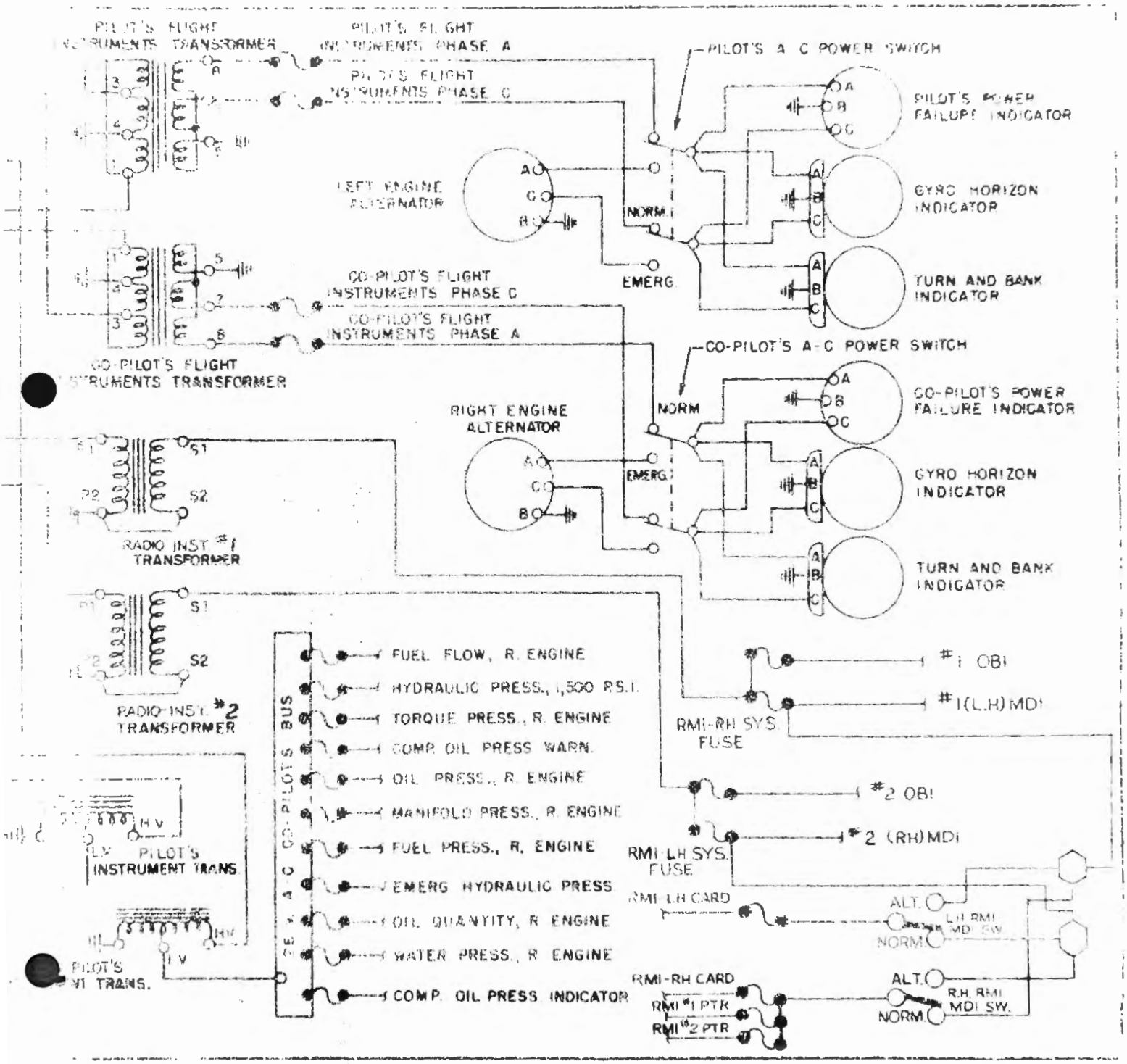


Figure 26. Battery Box And Cradle Support


PILOT'S FLIGHT INSTRUMENTS TRANSFORMER
PILOT'S FLIGHT INSTRUMENTS PHASE A
PILOT'S FLIGHT INSTRUMENTS PHASE C
PILOT'S A-C POWER SWITCH
PILOT'S POWER FAILURE INDICATOR
LEFT ENGINE ALTERNATOR
NORM
EMERG
GYRO HORIZON INDICATOR
TURN AND BANK INDICATOR
CO-PILOT'S FLIGHT INSTRUMENTS PHASE C
CO-PILOT'S FLIGHT INSTRUMENTS PHASE A
CO-PILOT'S FLIGHT INSTRUMENTS TRANSFORMER
CO-PILOT'S A-C POWER SWITCH
CO-PILOT'S POWER FAILURE INDICATOR
RIGHT ENGINE ALTERNATOR
GYRO HORIZON INDICATOR
TURN AND BANK INDICATOR
RADIO INST. #1 TRANSFORMER
RADIO INST. #2 TRANSFORMER
PILOT'S INSTRUMENT TRANS.
CO-PILOT'S BUS
FUEL FLOW, R. ENGINE
HYDRAULIC PRESS., 1,500 P.S.I.
TORQUE PRESS., R. ENGINE
COMP. OIL PRESS WARN.
OIL PRESS., R. ENGINE
MANIFOLD PRESS., R. ENGINE
FUEL PRESS., R. ENGINE
EMERG HYDRAULIC PRESS
OIL QUANTITY, R. ENGINE
WATER PRESS., R. ENGINE
COMP. OIL PRESS INDICATOR
#1 OBI
#1 (L.H.) MDI
RMI-RH SYS. FUSE
#2 OBI
#2 (RH) MDI
RMI-LH SYS. FUSE
RMI-LH CARD
ALT.
L.H. RMI MDI SW.
NORM.
RMI-RH CARD
RMI #1 PTR
RMI #2 PTR
ALT.
R.H. RMI MDI SW.
NORM.

...tem Schemat

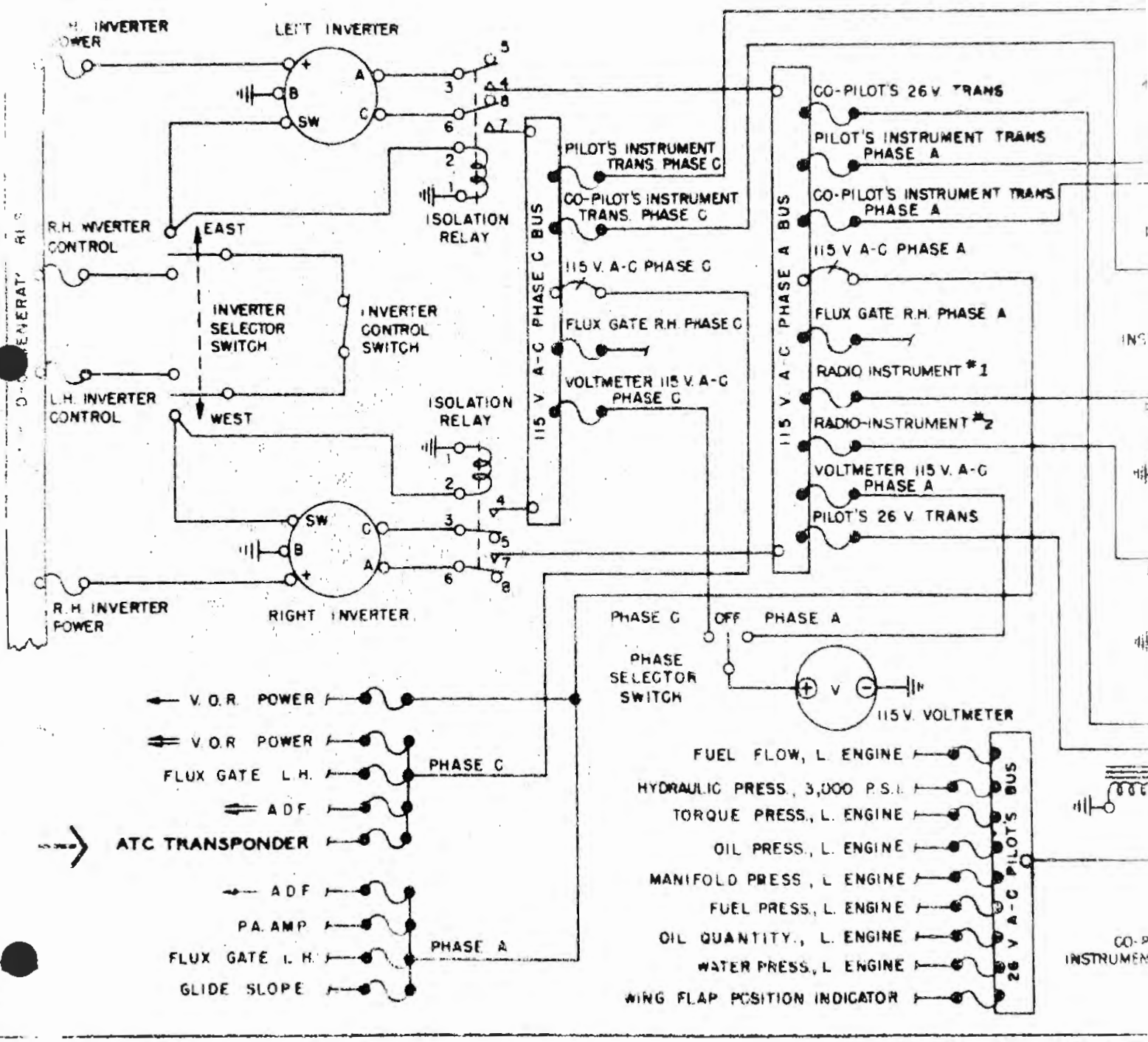


Figure 25 A-C Power Sys

Generator Capacity

The generators cannot be expected to operate at full capacity on the ground because of reduced engine speeds and lack of adequate ram air for proper cooling. The following limitations should be adhered to:

Minimum Eng. RPM	Amperes Load Per Generator	Time Limit
1000	210	15 min.
1000	160	30 min.
7000	135	45 min.

The above restrictions apply only to continuous loading. Intermittent heavy loads of one-half minute duration can be handled satisfactorily. Never use generators below 1000 engine RPM, nor should they be used to start engines.

Single Generator Check

Generator voltage should be 27.5 ± 0 - .25 volts at all engine speeds and load conditions.

Paralleling Generator Check

With both engines running at 1500 RPM apply a load of 200 amperes total by turning on recirculating fans, inverters, radio lights etc. and note voltmeter and ammeter indications. Voltmeter should indicate 27.5 ± 0 - .25 volts and ammeters should indicate within 20 amperes of each other.

Generator Maintenance

Remove the inspection band and check brush length and condition of commutator. If the brushes are worn to a point 3/8" below the top of the brush holder, or the commutator is burned, pitted or heavily scored, replace the generator. Check the internal air passage for being free of any obstruction preventing proper air cooling. Check the air blast tube supplying the generator for being free of damage, kinks, foreign particles, etc.

Approved Generators

Eclipse Pioneer 30E02-9 and -11 generators shall be used as standard equipment. This will permit use of the generator overheat circuit provided on these aircraft. When an Eclipse generator is installed the plugstat (temperature sensing element) must be installed and the overheat circuit made operable.

The General Electric generator type 2CM75 may be installed if the Eclipse type 30E02 is not available. When a General Electric generator is installed the overheat light lead is to be taped and stowed. The applicable overheat warning light shall be placarded with a typewritten placard stating "Generator Overheat Circuit Inoperative".

Battery Maintenance

Examine the vent holes in the filler caps and the vent connection in the battery cover to see that they are free of any obstruction. Any battery vapor will leave the airplane by way of the vent tube. Check condition of the pad under the battery that has been soaked in bicarbonate of soda and dried. Any electrolyte escaping from the battery is absorbed by the pad. Examine the male and female connectors on the battery and the battery cover and the condition of the cables connected to the binding posts on the cover. Remove corrosion from connector with a stiff brush and wash with a solution of sodium bicarbonate. Rinse with water. Keep vent caps on battery while rinsing off. Remove the filler cap from each cell and check water level and specific gravity with a hydrometer. Water level should be 1/8" above the top of the plates. Use distilled water to fill the cells. For a fully charged battery, the hydrometer should read between 1285 and 1300 for each cell tested. If the reading is as low as 1250 for any cell the battery must be recharged.

Caution

Slip two pieces of 5/8" rubber hose about 4" long over the battery terminals at all times when removing or replacing the battery to prevent possible arcing against structure. Never release the battery cradle lock pin without a battery installed. The cradle is heavily spring loaded, and damage to structure and possible personal injury will result. Always observe the placard on the carriers.

Line Maintenance of Inverter.

Check the brushes of the d-c motor of the inverter to see if they are too short or have physical defects. Brushes should be replaced if they are worn so that the brush holder spring is within 1/8 inch of the bottom of the slot in the brush holder. When fitting a new brush it must be fitted by operating the inverter with a no-load output until at least 3/4 of the brush face is in contact with the commutator. The brushes must fit freely in the brush slots without excessive side play. Binding brushes and brush slots should be cleaned by wiping with a cloth moistened with unleaded gasoline or other suitable solvent, and then wiped with a clean non-linting cloth.

CAUTION

Do not use carbon tetrachloride as its use will cause rapid brush wear.

Check the commutator for contamination, burning, or excessive wear. The commutator can be cleaned of contamination with a fine No. 4/0 sandpaper and then cleaned off with dry compressed air.

The original inverter adjustments at the factory should make any further adjustments unnecessary when installing a new inverter. Any desired change in frequency or voltage by a small amount should be done by airline specialists only at an overhaul shop. Faulty units should not be disassembled on the line, but forwarded to authorized repair or overhaul shops for inspection, test and repair.

LAMP USAGE CHART

Use	Bulb Type	Bulb No. Req.	Filter Assembly Color	Filter Assembly P/N	Location
Warning & Indicator Lts.					
Altitude Reset Ind. Lt.	313	1	Amber Non-Dimming	130-AAL	Co-Pilot's Console
ADI Press. Warn. Lts.	313	2	Red Non-Dimming	130-ARL	Upper Center Inst. Panel
Auto-Feath. "Armed" Ind. Lts.	313	2	Amber-Dimming	130-SAL	O'Head Sw. Panel
Auto-Feath. "ON" Ind. Lts.	313	1	Red Dimming	130-SRL	O'Head Sw. Panel
Batt. Reset Sw. Ind. Lt.	313	1	Red Non-Dimming	130-ARL	Pilot's Console
Cabin Heat Cycling Lts.	313	2	Green-Dimming	130-SGP	O'Head Sw. Panel
Cabin O'Heat Ind. Lts.	313	2	Red Non-Dimming	130-ARL	O'Head Sw. Panel
Combustion Blower Lts.	313	2	Amber-Dimming	130-SAL	O'Head Sw. Panel
Deviation Ind. Lts.	313	4	Amber-Dimming	130-SMAL	Co-Pilot's Inst. Panel & Pilot's Inst. Panel
External Power Conn. Lt.	313	1	Green Non-Dimming	130-AGL	O'Head Sw. Panel
Fire Warning Lts.	313	18	Double Red Non-Dimming		Glare Shield
Fluxgate Caging Ind. Lts	313	2	Red Non-Dimming	109-ARL	Pedestal
Fuel Press. Warn. Lts.	313	2	Red Non-Dimming	130-ARL	Upper Center Inst. Panel
Gen. Field Trip Ind. Lts.	313	2	Red Non-Dimming	130-ARL	O'Head Sw. Panel
Gen. O'Heat Ind. Lts.	313	2	Red Non-Dimming	130-ARL	O'Head Sw. Panel
Heater Cycling Lts. Anti-Icing	313	4	Green-Dimming	130-SGP	Anti-Icing Panel Co-Pilot's Console
Heater O'Heat Lts. Anti-Icing	313	4	Red Non-Dimming	130-ARL	Anti-Icing Panel Co-Pilot's Console
Land. Gear Ind. Lts.	313	3	Green-Dimming	130-SGL	Lwr. Center Inst. Panel
Land. Gear Ind. Lts.	313	1	Red Non-Dimming	130-ARL	Lwr. Center Inst. Panel
Main Doors Ind. Lt.	313	1	Red Non-Dimming	130-ARL	Co-Pilot's Console
Marker Beacon Lt.(Left)	1811	1	White-Dimming	103-SWL	Pilot's Inst. Panel
Marker Beacon Lt. (Center)	1811	1	Amber-Dimming	103-SAL	Pilot's Inst. Panel
Marker Beacon Lt.(Right)	1811	1	Blue-Dimming	103-SBL	Pilot's Inst. Panel
Oil Pressure Warn. Lts.	313	2	Red Non-Dimming	130-ARL	Upper Center Inst. Panel
Parking Brake Ind. Lt.	313	1	Red Non-Dimming	130-ARL	Left Inst. Panel
Phone Call Ind. Lt.	313	1	White Non-Dimming	130-AWL	R.H. Inst. Panel
Pitot Heater Ind. Lts.	313	2	Amber-Dimming	130-SAL	O'Head Sw. Panel
Primary Comp. Oil Press. Warn. Lt.	313	1	Red Non-Dimming	130-ARL	Co-Pilot's Console
Prop. and Carb. De-Icing Ind. Lt.	313	1	Amber Dimming	130-SAL	O'Head Sw. Panel
Prop Feathering Lts.	320A	2	Red Non-dimming	Neath. Sw. Knob	O'Head Sw. Panel
Prop. Range Limit Warn. Lts.	313	2	Amber-Dimming	130-SAL	Pedestal
Prop. Reverse Ind. Lts.	313	2	Amber-Dimming	130-SAL	Pedestal
Service Doors Ind. Lts.	313	1	Red Non-Dimming	130-ARL	Co-Pilot's Console
Stabilizer Out-Of Phase Ind. Lt.	313	1	Red Non-Dimming	130-ARL	Upper Center Inst. Panel
Terrain Warn. Lts. (2000)	313	2	Orange-Dimming	1-43791-4	Pilot's L.H. Inst. Panel & Co-Pilot's R.H. Inst. Panel
Terrain Warn. Lts.(1000)	313	2	Yellow-Dimming	1-43791-3	Pilot's L.H. Inst. Panel & Co-Pilot's R.H. Inst. Panel
Terrain Warn. Lts. (500)	313	2	Red-Dimming	1-43791-1	Pilot's L.H. Inst. Panel & Co-Pilot's R.H. Inst. Panel

LAMP USAGE CHART (CONT.)

Use	Bulb Type	Bulb No. Req.	Filter Assembly Color	Filter Assembly P/N	Location
Flight Station					
Cockpit O'Head Dome Lt.	3071F	1	Frosted White		O'Head Lt. Panel
Co-Pilot's Console Lt.	313	1	Red (No Shield)	40-1580222*	Co-Pilot's Lwr. Windshield Sill
Co-Pilot's Floor Lts.	303R	2	None	---	Co-Pilot's Kick-plate
Co-Pilot's Kit Comp. Lt.	313	1	Red (No Shield)	40-1580222*	Co-Pilot's Lwr. Windshield Sill
Co-Pilot's Reading Lt.	3071F	1	None	---	O'Head Lt. Panel
Co-Pilot's Red.Instr. Panel Lts.	313	1	Red (Shield #7)	404-6070276-19*	Glare Shield With Chain
Co-Pilot's Red Inst. Panel Lt.	313	1	Red (Shield #5)	404-6070276-39*	Under Glare Shield Most Outboard
Co-Pilot's Red Instr.Panel Lts.	313	1	Red (Shield #1)	404-6070276-19*	Under Glare Shield 3rd from Outboard
Co-Pilot's Red Instr. Panel Lts.	313	1	Red (Shield #8)	404-6070276-50*	Under Glare Shield 4th From Outboard
Co-Pilot's Red Instr. Panel Lts.	313	1	Red (Small Glass Dome)	911310-93	Under Glare Shield
Co-Pilot's Red Instr. Panel Lts.	304	1	Red	404-6070224-15	Glare Shield Center Box
Instr. Panel White Lts.	313	1	Clear (Shield #3)	404-6070276-29*	Glare Shield L.H.
Instr. Panel White Lts.	313	1	Clear (Shield #4)	404-6070276-30*	Glare Shield R.H.
Instr. Panel White Lts.	302	2	None		Glare Shield L.H. & R.H.
Instr. Panel White Lts.	304	1	Clear Baffle Only	404-6070224-23	Glare Shield Center Box
O'Head Sw. Panel Lts.	309	2	Red	404-6081119	Door Coaming
Pilot's Circ. Brker Panel Lts.	313	2	Red (No Shield)	40-1580222*	Pilot's Circ. Brkr. Panel
Pilot's Console Lt.	313	1	Red (No Shield)	40-1580222*	Pilot's Lower Windshield Sill
Pilot's Floor Lts.	303R	2	None	---	Pilot's Kick-plate
Pilot's Kit Comp. Lt.	313	1	Red (No Shield)	40-1580222*	Pilot's Lower Windshield Sill
Pilot's Reading Lt.	3071F	1	None	---	O'Head Lt. Panel
Pilot's Red Instr.Panel Lts	313	1	Red (Shield #1)	404-6070276-19*	Glare Shield With Chain
Pilot's Red Instr. Panel Lts.	313	1	Red (Shield #5)	404-6070276-39*	Under Glare Shield Most Outboard
Pilot's Red Instr.Panel Lts	313	1	Red (Shield #1)	404-6070276-19*	Under Glare Shield 3rd From Outboard
Pilot's Red Instr.Panel Lts	313	1	Red (Shield #7)	404-6070276-49*	Under Glare Shield 4th from Outboard
Pilot's Red Instr.Panel Lts	313	1	Red (Small Glass Dome)	911310-93	Under Glare Shield
Pilot's Red Instr.Panel Lts	304	1	Red	404-6070224-15	Glare Shield Center Box
Radio Control Box Panel Lts	327	3	---	---	Pedestal
Radio Dial Lts.	325	7	---	---	Pedestal
Radio Panel (Pedestal)Lt.	3071F	1	Red	404-6083093-1	O'Head Lt. Panel
Standby Compass Lts.	327	2	Red	---	Center of Upper Windshield

*Rubber hooded type.

Procedure	Special Instructions
NOTE: Since the generator control panels containing the voltage regulators are located in the electrical hatch and are not accessible from the cockpit, it will require two mechanics to perform a generator adjustment procedure.	CAUTION: Load and time limits for ground operation of generators must be observed to prevent damage by overheating. Se. Series 24-3 in this chapter for l 1 limits.
1. Connect an accurate portable voltmeter on the test jacks of the generator control panel being adjusted.	
2. Place the battery switch in the "Bat" position and remove the external power source.	
3. Turn both generator switches momentarily to the reset position, then to the on position.	
4. Apply approximately a 50 ampere load and allow the generator to operate for at least 10 minutes at 1500 engine RPM.	4. This will allow the regulators to reach operating temperatures. Never attempt to adjust a cold regulator.
5. Turn both generator switches to the off position.	
6. With both generator switches in the off position, adjust the no-load voltage of both regulators by turning the respective knurled nut of the regulator rheostat.	6. Measurement to be made with a accurate v - meter at the regulator jacks. Adjust vo -ge to 27.5 volts. Counter-clockwise rotatic of the knurled nut will lower voltage. Clockwise will raise the voltage.
7. Turn one generator on and apply 200 ampere load at 1500 engine RPM. Check for rising or dropping voltage characteristic.	7.7. Voltage should not rise, nor should the drop be more than 0.5 volts. A flat or slightly drooping characteristic is desirable. An excessive voltage shift over full load and speed range indicates a malfunctioning regulator which should be replaced.
8. Repeat Step 7 with the other generator.	
9. Turn both generators on and apply 200 ampere load at 1500 RPM. Note generator voltmeter and ammeter readings after one minute of operation.	9. Ammeters should not be more than 20 amperes apart and voltmeter should read 27.5 ∕ 0 - .25 volts.
10. If generators unbalance is greater than specified in Step 9, lower the voltage output of the generator carrying the high amperage and raise the voltage output of the generator carrying the low amperage by turning the rheostat knob one notch at a time.	
11. Turn the load on and off several times and check to see that regulators remain in balance as specified by Step 9.	
12. Make a final check of the bus voltage to insure that it has not been raised above 27.5 volts while the regulators were being adjusted.	

Procedure

Connection or disconnection of electrical power to the aircraft shall be accomplished by qualified personnel only after authorization by supervisory personnel in charge of the operation who shall ascertain that no hazard will exist if electrical power is connected.

(1) At Stations where Foreman are available, the Foreman-In-Charge of the operation or his designated representative shall authorize connection of electrical power to the aircraft

(2) At stations where Foremen arenot available, senior maintenance personnel on duty shall grant such authorization.

Prior to hangaring or performing any major maintenance operation on any aircraft, the electrical and radio systems must be completely de-energized as follows except in cases where the specific approval of Supervisor in charge of aircraft is obtained to deviate from this procedure.

Place the battery master switch in the off position.

Lower batteries to the disconnected position.

Insert a dummy plug in the external plug-in receptacle. This dummy plug will bear a placard reading, "Do Not Remove. See Foreman". If dummy plugs are not available, a red tag shall be installed at the external power plug reading, "Do Not Connect External Power. See Foreman".

Prior to connecting ground power or placing batteries in the connected position, disengage and/or disconnect the following unless otherwise authorized by Supervisor-In-Charge of Aircraft.

Airscoop Blanket Circuit Breaker #66	Forward Distribution Circuit Breaker Panel
Starter Circuit Breaker #85	Forward Distribution Circuit Breaker Panel
Auto Feather Circuit Breaker #109	Forward Distribution Circuit Breaker Panel
Heated Torquemeter Circuit Breaker #83 & #107 .	Forward Distribution Circuit Breaker Panel
1 - D.C. Pitot Heater Circuit Breaker	Forward Distribution Circuit Breaker Panel
All D.C. Load Control Switches on Overhead Panel	
All Circuit Breakers on Essential and Emergency Bus	

With the specific approval of the Supervisor-In-Charge of Aircraft, it is permissible to work on certain circuits and areas with power supplied to the aircraft providing the circuit and the area can be completely isolated by circuit breakers, during which time these circuit breakers, during which time these circuit breakers must be tagged with a red tag, reading, "Do Not Turn On Working in Area". Power can also be restored to previously de-energized circuit, for test purposes, etc., providing it does not conflict with the provisions listed below.

When any of the following operations are being accomplished during the course of Line Maintenance, the electrical system must be de-energized.

NOTE: On all aircraft, place the battery selector switch in the "OFF" position. Disconnect the battery by raising the battery cover and attach a red tag reading, "Do Not Install, See Foreman". On all aircraft, remove external power and install a tag reading, "Do Not Connect External Power. See Foreman"

(1) Removal of any electrical instrument, radio, or other unit requiring electrical power for its operations which cannot be isolated by opening circuit breakers.

(2) Maintenance work being performed at any of the following locations: (Maintenance work shall be construed to mean electrical, radio, electrical instrument, aircraft work, or structural repairs.)

Procedure (Cont.)

a. In the nacelle or engine junction box or when the cover is removed.
b. In the flight station electrical, instrument, or radio panels
c. In the belly electrical compartment.
d. In the cabin heater junction box
e. In the radio junction box.
f. In the anti-ice heater junction box.
g. In the vicinity of any high current bus or electrical unit.
h. In the nosteer electrical control panel.

Radio transmitters shall not be operated while the aircraft is being fueled or de-fueled

When functionally testing electrical units dependent on structure for a ground circuit, they shall be properly attached to structure and in no case shall a ground circuit be established by touching the unit case or frame to structure.

Prior to releasing the aircraft for service, Supervisor-In-Charge of Aircraft shall make certain that power has been restored to all circuits previously de-energized and all tags have been removed.

Whenever a unit is changed or a line is disconnected on an aircraft or engine, wherein combustible fluid may be spilled and the movement of tools or parts in the area might cause a spark if contact is made with an electrical connection, the power to the circuit or circuits in the immediate work area shall be turned off.

This precaution shall also apply to cleaning or spraying operations in which combustible vapors may be formed and any possibility exists of accidental shorting or grounding of fire warning units, open terminal strips, cannon plugs, or any other source of electrical power which might produce a spark.

In the case of fire warning circuits which are powered directly from the bus, regardless of the position of the battery switch, the appropriate circuit breakers shall be turned off.

It shall be the responsibility of the mechanics performing the above work to make certain that power has been restored to the circuits deactivated before the aircraft is dispatched.